SERVICE MANUAL

11001 M

For the Brown Type 113
Mechanical Potentiometer
and
Resistance Thermometer

MINNEAPOLIS-HONEYWELL REGULATOR CO.
Industrial Division
PHILADELPHIA 44, PA.

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY
Brown Instruments Division
PHILADELPHIA 44, PENNSYLVANIA

INSTRUCTION MANUAL

SERVICE MANUAL FOR THE BROWN TYPE 113
MECHANICAL POTENTIOMETER AND RESISTANCE THERMOMETER

100

CONTENTS

Section 1353 Principles of Operation
Section 1354 Mechanical Operation of Single Record Potentiometer
Section 1355 Mechanical Operation of Multiple Point Print Hammer Potentiometer
Section 1356 Mechanical Operation of Multiple Point Print Wheel Potentiometer
Section 1357 Principles of Operation of Control Mechanisms
Section 1358 Description of and Data on Component Parts of Type 113 Mechanical Potentiometer
Section 1359 Mechanical Adjustments and Corrective Data
Section 1360 Electrical Adjustments and Corrective Data
Section 1361 Control Adjustments and Corrective Data
Section 1362 Maintenance
Section 1309 Lubrication

Number 11001M Issue 3

USER'S RECORD

Model No._____ Serial No._____ Location_____

Date Installed_____ Wiring Diagrams_____

Other Instructions_____

SECTION 1353
Issue 1

PRINCIPLES OF OPERATION OF THE BROWN POTENTIOMETER TYPE INSTRUMENTS BALANCING MECHANISM

A close study of the information contained in this service manual will enable the operator to obtain the best possible service from this type of instrument.

A. ELECTRICAL OPERATION

A potentiometer consists of a calibrated slidewire resistor through which a measured or standard current is passed, thus providing a calibrated voltage drop across the slidewire. A portion of this voltage determined by the position of the slidewire contactor, is opposed to the voltage generated by a thermocouple or radiation pyrometer. When these two voltages are equal the position of the slidewire contactors, which is connected to an indicating pointer, indicates the temperature of the thermocouple or radiation pyrometer on the slidewire scale, as this scale is graduated in degrees of temperature. This condition of equality or balance is determined by a D'Arsonval galvanometer which indicates balance or equality of voltage.

When the voltages are not equal, the self balancing potentiometer pyrometer recognizes this condition of unbalance, determines its magnitude and direction, and corrects the slidewire contactor position, thus reducing the voltage difference to zero and indicating the temperature.

B. MECHANICAL OPERATION

An unbalance between the emf of the thermocouple circuit and the emf of the potentiometer circuit causes the galvanometer pointer to deflect away from the neutral or mechanical zero position.

The deflection of the galvanometer pointer is detected by the galvanometer step table. The elevation of the step table is transmitted through a series of levers to the step lever on the right-hand side plate. The step lever changes position of the slidewire contactor until the emf of the potentiometer circuit balances the emf of the thermocouple circuit.

The pen or print carriage is connected through a spiral shaft and spur gear to the slidewire and is moved across the scale to the correct temperature reading as the potentiometer circuit is brought to the balanced position.

MECHANICAL OPERATION OF THE SINGLE RECORD POTENTIOMETER

The mechanical operation of the Single Record instrument can be broken up into two parts: the balancing mechanism and the recording mechanism. These are described in detail as follows:

A. BALANCING MECHANISM

The hardened kidney cam, revolving once every 3.6 seconds, raises the step lever assembly. This allows the secondary pointer to take a position determined by the position of the galvanometer pointer on the galvanometer step table.

The height of the step table "C" Fig. 1354-1 is transmitted through the galvanometer table lever shaft "F" and galvanometer table lever "K" thus positioning the secondary pointer "D".

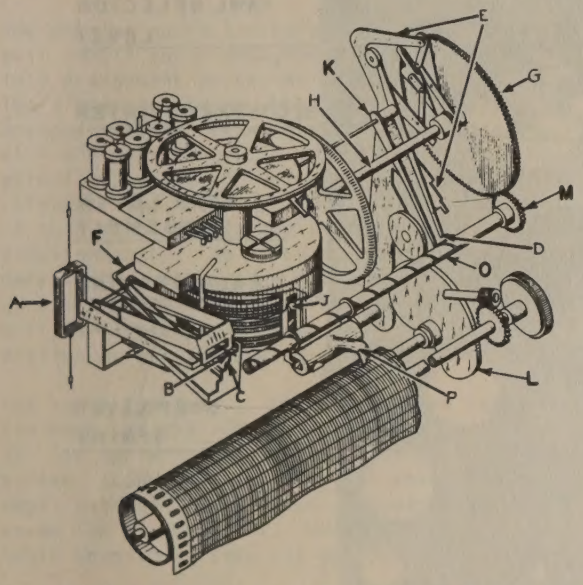


Fig. 1354-1 The Brown Operating Principle

A motor driven kidney cam "L" operates the above mechanism and drives the step lever "E" upward periodically. A spring then moves it downward until it is stopped by the secondary pointer "D".

As the step lever "E" starts to move downward, one of the pawls, fastened to the end of the step lever, is thrown into engagement with the large spur gear "G" by the pawl selector lever, which has been positioned by the secondary pointer "D".

The step lever "E" continues to move downward driving the large spur gear "G" until a step on the step lever contacts the secondary pointer "D".

Each step on the main step lever represents a movement of a definite number of teeth on the large spur gear; that is, 0, 1, 3, 10, 22, 44, and 80 teeth correspond to the neutral, 1st, 2nd, 3rd, 4th, 5th, and 6th steps on either side of neutral, The longest step gives the spur gear a movement of 80 teeth, which corresponds to an angular movement of that gear of about 120°.

The selector lever Fig. 1354-2 which clamps the secondary pointer just before the main step lever contacts it, does so on one of its two steps. The particular step selected depends upon whether the secondary pointer is above or below the neutral step on the step lever, which depends upon whether the galvanometer pointer is to the left or to the right of the neutral step on the step table, respectively.

The hub of the selector, where it is fastened on its bearings, carries the drive pawl spring, which positions one of the two drive pawls to cause that particular pawl to contact the large spur gear. This spring is positioned so that it will throw alternate pawls into engagement with the large spur gear when the secondary pointer is moved from 1 step below neutral to 1 step above neutral.

The two drive pawls shown in Fig. 1354-2 are driven by means of the upper and lower drive pawl links connected to the main step lever assembly. The step lever assembly is raised to its highest position by the kidney cam. At this point, the drive pawls are in their neutral position with the drive pawl spring mid-way between them. In rising, the main step lever pulls up on the selector lever which unclamps the secondary pointer. The secondary pointer drops back in time to be brought forward by the table lever. The table lever now moves the secondary pointer into position. The main step lever starts downward, releasing the selector lever, which clamps the secondary pointer due to the tension exerted by the pawl selector lever spring. In moving to the clamping position, the selector lever moves the drive pawl spring which causes one of the drive pawls to engage the large spur gear. The step lever assembly continuing its motion, drives the pawl which is

in contact with the spur gear until stopped by the step lever contacting the secondary pointer. The entire mechanism is spring driven and the motor merely resets the spring.

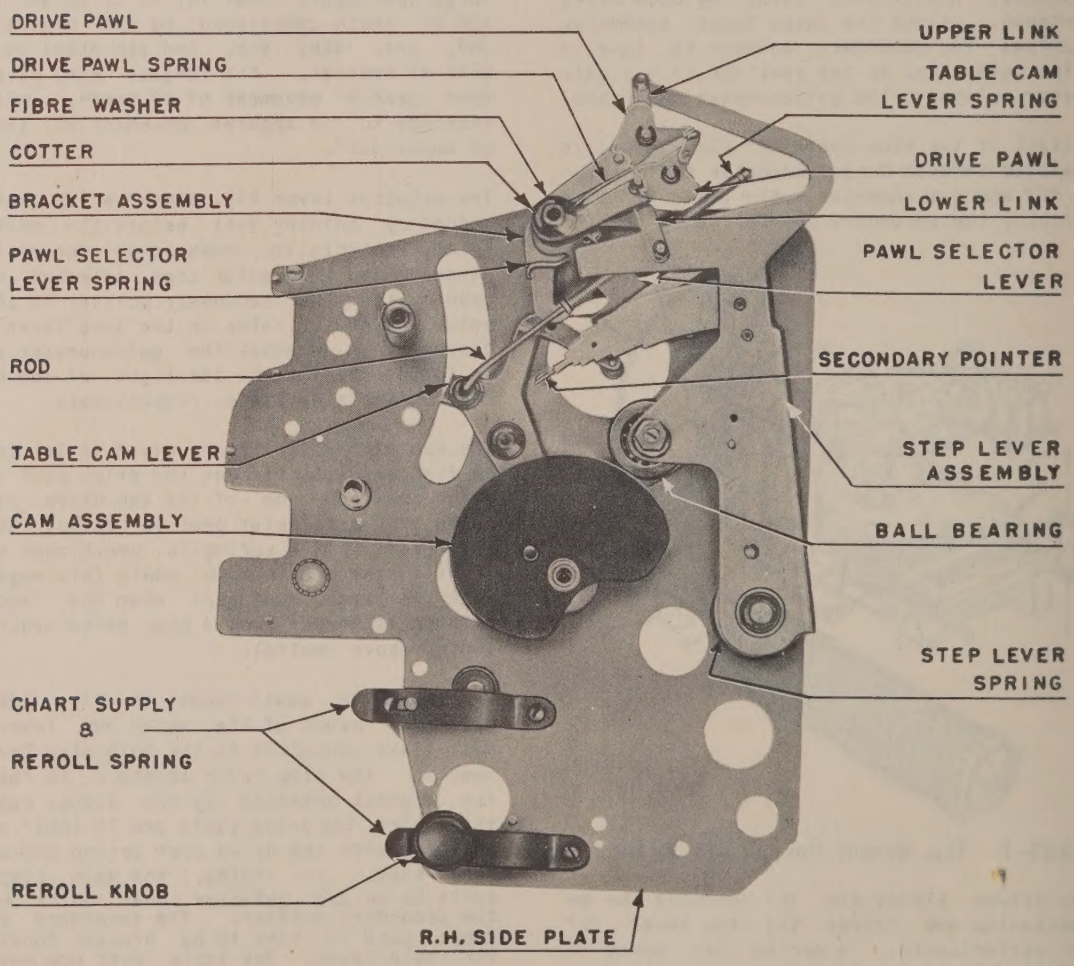


Figure 1354-2
Right-Hand Side Plate Single Record Instrument
Large Spur Gear Removed

One important feature of the main step lever spring drive is that the spring is amply strong to move the large spur gear under normal conditions. Under abnormal conditions, as when the pen reaches the end of the scale, the spring merely ceases to move the main step lever any further. Thus, it is not necessary to provide for slippage in the clutch, and the use of the positive pawl type clutch is made permissible.

In the initial part of the driving stroke of the main step lever, while the selector lever is being released, the pivot points on the pawls and their connecting links are in straight lines passing through their dead center position so that no motion is imparted to the pawls. Accordingly, the main step lever has to pass through relatively larger angular distances to advance the pawls and spur gear through the first few teeth than in the more advanced positions. A step lever motion of 5/16" is required to advance the spur gear through one tooth, which moves the pen through 0.0093".

The driving pawls are balanced on their axes and will remain out of engagement except when pushed into engagement by the drive pawl spring. During a driving stroke of the main step lever, the engaged pawl is drawn tightly into engagement with the gear on account of its geometrical construction, while on the return stroke the pawl releases its hold and goes out of engagement. If both pawls should be thrown into engagement simultaneously, as by hand, the drive spring merely does not move the main step lever on that stroke and at the end of the cycle both pawls will be disengaged and made ready for proper operation on the succeeding cycle.

The table cam lever, operated by the table cam (in back of the kidney cam), does two things in its cycle of operation. In its forward stroke (counter-clockwise) it moves the paper feed ratchet and in its backward stroke it moves the table lever, which pushes the step table down to unclamp the galvanometer pointer.

B. RECORDING MECHANISM

When the large spur gear rotates it causes the small 54-tooth spur gear or pen shaft gear to rotate. The pen shaft gear is fastened to a stainless steel spiral shaft which has a half-inch pitch helical V groove cut in it. This shaft drives the pen carriage in a positive manner. Exactly 22 turns of this spiral shaft moves the pen a full scale distance of eleven inches. Thus, a driving pawl, operating upon the periphery of the large 236-tooth spur gear, drives through a total linear distance of about 66 inches to move the slidewire contactor 42½ inches and the pen 11 inches. When the driving pawl moves the large gear through the distance of one tooth (.056" or nearly 1/16"), the pen is advanced through its smallest step of less than a hundredth of an inch (.0093"). The largest pen step, corresponding to an advance of 80 teeth, is .740".

Figure 1354-3 shows the 6-step adjustable chart speed arm which governs the number of teeth taken on each stroke of the table cam lever.

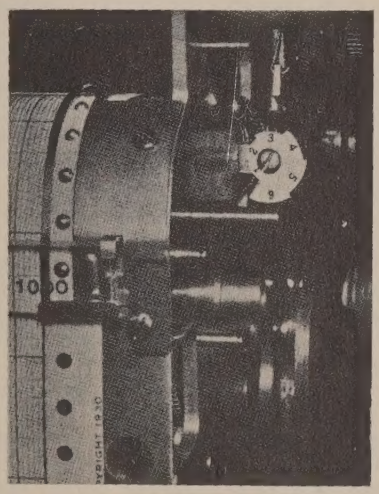


Figure 1354-3
Chart Speed Cam

This lever in its downward or forward stroke contacts the cam, moving it along to the end of its stroke. The sooner the cam is contacted, the farther it will move. The farther the cam moves, the more teeth it takes on the ratchet and the farther the chart is moved. Each tooth of the ratchet is equivalent to 1 inch of chart per hour. The speed of the chart can be varied readily by loosening the clamping screw and revolving the step cam until the desired chart speed figure falls underneath the operating lever. The numbers on the cam indicate inches of chart speed per hour. The standard chart speed is 2 inches per hour.

MECHANICAL OPERATION OF THE MULTIPLE POINT PRINT HAMMER POTENTIOMETER

The mechanical operation of the Multiple Point Print Hammer Instrument can be broken up into two parts: the balancing mechanism and the recording mechanism. These are described in detail as follows:

A. BALANCING MECHANISM

The balancing mechanism is the same as that which is described in the section, "Mechanical Operation of the Single Record Potentiometer".

B. RECORDING MECHANISM

The chart drive and print carriage drive is the same as on the single record recording mechanism.

The recording mechanism has a print hammer and a multicolored ribbon instead of a pen. Different records are printed in three different colors and three different color combinations, making a total of six easily distinguishable records. A thermocouple selector switch is provided with a dial having colored sections and corresponding numbers showing which thermocouple is connected to the recorder, and which color or combination represents each couple. The entire printing and switching operation takes place during one cycle of operation of the recording mechanism, minimizing the time consumed in recording and leaving the entire record clearly exposed to view.

No. of Records	SWITCH POINT NUMBER					
	1	2	3	4	5	6
2	Green	Red				
3	Green	Red	Purple			
4	Green	Red	Purple	Red and Purple		
6	Green	Red	Purple	Red and Purple	Green and Purple	Green and Red

The time interval after a thermocouple has been connected until the recording occurs is varied by means of a selective mechanism so that the lapse of a predetermined time interval is not necessary. This results in more frequent recordings and more legible records. Without this feature, enough time should be allotted to each circuit to allow the print hammer to move to the opposite end of the scale if necessary and reach a balanced position. Obviously, this is much more time than is usually required. This selective mechanism has two sectors which are used to engage a printing tripper which actuates the print hammer and thermocouple switch.

A fine tooth sector called the "unbalanced ratchet sector" is advanced one tooth on each cycle, and a coarse-tooth sector called the "balanced ratchet sector" is permitted by a shield to advance only when the instrument is in balance. The selection of one of the two sectors is governed by a shield placed in front of the sectors. When the potentiometer is balanced, the secondary pointer will be placed opposite the long middle step of the main step lever, which stops the step lever in a definite position. A locating pin on the step lever now prevents the shield from dropping. A driving pawl is now permitted to engage the coarse-tooth sector directly and advance it regardless of the fine tooth sector. Two movements of the coarse tooth sector advance the tripper far enough to cause the instrument to print. The sectors are them automatically reset. When the pin on the step lever allows the pawl shield to drop, the pawl engages a tooth on the fine tooth sector. This sector has 20 teeth, which allow a maximum of 20 unbalanced strokes to occur before it advances far enough to cause the instrument to print in an unbalanced position. If, after a number of unbalanced strokes, we have one balanced stroke, the printing will not occur until the instrument has found either a second balance stroke or has accumulated a total of twenty unbalanced strokes. The reason for providing the fine tooth ratchet in addition to the coarse tooth ratchet is that it may be impossible at times for the recorder to reach a balanced position for one of the thermocouples, as for instance, when the range of the instrument is from 800 to 1800°F and the thermocouple is at a maximum temperature of 400°F. The fine tooth ratchet allows a definite maximum time to each thermocouple, after which the record is made and the next succeeding thermocouple is connected whether the galvanometer

reaches a balanced position or not. By the use of the small adjustable numbered cam (shown in Fig. 1355-1), the maximum printing cycle of the instrument can be set from six up to twenty strokes. The advantage of this feature on a multi-point controller where the controlled temperatures are reasonably close together is obvious, as only a few strokes are required to reach the balanced position and pass over to the next point. This is valuable where time is an important factor in obtaining close control.

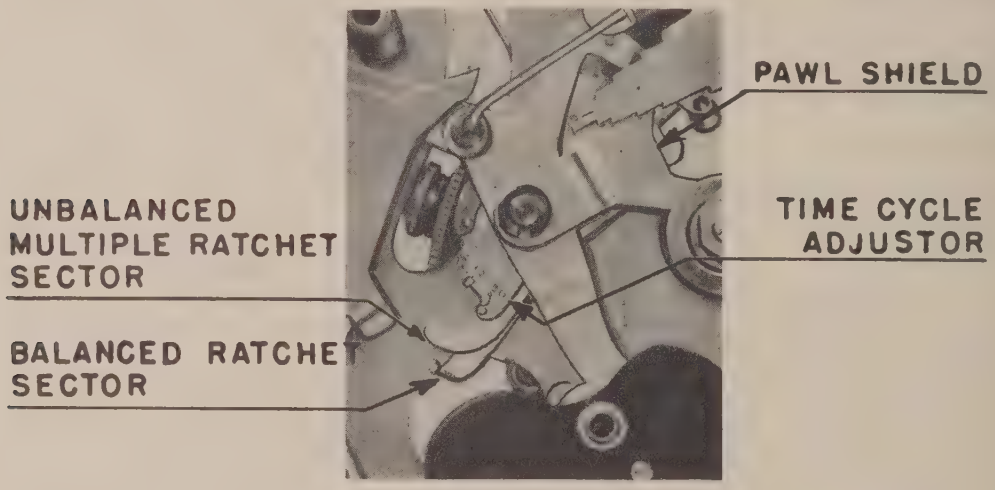


Fig. 1355-1 - Pawl Shield and Multiple Table Cam Lever Assembly

When the drive pawl has moved the balanced or unbalanced ratchet sectors through the predetermined number of steps, the balanced ratchet extension assembly moves the tripper so that it is positioned under the multiple table cam lever. These parts are shown in Fig. 1355-2. When the multiple table cam lever takes its next stroke, it pushes the tripper down. This causes the oil switch pawl to move the color cam ratchet wheel assembly one tooth. The ratchet is prevented from moving back by the retaining pawl, connected to the print hammer lever. The print hammer lever in rising upon, then dropping off, a tooth on the ratchet, causes the print hammer to rise then drop to make a mark on the chart, through the ribbon. This action from the print hammer lever to the print hammer is made by means of a link connection to the humidity compensator bar. The tripper assembly in its downward movement also sweeps the ratchet sectors back and resets them for a new cycle of operation.

The multi-colored ribbon reroll is driven by a gear on the chart drum. The ribbon is rerolled in direct proportion to the speed of the chart roll; that is, the ribbon will run out about one day after the entire chart has run through. The ribbon should be renewed at the same time the chart is renewed.

The supply ribbon reel has been provided with a friction spring which applies the proper friction to prevent the ribbon from curling. It is very important that the ribbon be renewed after having been run through once. Rollers have been provided on the ribbon carriers so that a greater tension may be applied on the spring on the left-hand ribbon stud, without increasing the pull on the driving stud. If this spring exerts too great a tension, the ribbon will tighten up, causing the ribbon carriers to pull together, which will prevent a free motion of the carrier when it drops down to position a definite color under the print hammer. The gear which drives the ribbon reroll from the left-hand side of the chart drum is fastened onto the reroll stud with a left-hand screw thread.

Before the instrument is ready to print, the printing selector lever locks the ribbon carriage so that the ribbon uncovers the last mark made on the chart. When the printing cycle has been completed, the multiple tripper contacts the printing selector lever which unlocks the ribbon carrier. The ribbon carrier falls by gravity until the pin on the right-hand side contacts the printing color selector cam. This cam has three different heights, which allows

three different stopping places for the ribbon carrier, each of which places a different color of the three-color ribbon under the print hammer. The ratchet wheel and printing color selector cam revolves one-half turn as the oil switch goes through one complete cycle. This allows for the combinations of colors which are obtained.

The print hammer, which makes a single dot on the chart, can be fitted with a stylus which produces a dot inside of a circle. The large circle-dot record is easier to read from a distance. If the print hammer does not strike the ribbon properly, it can be bent to do so.

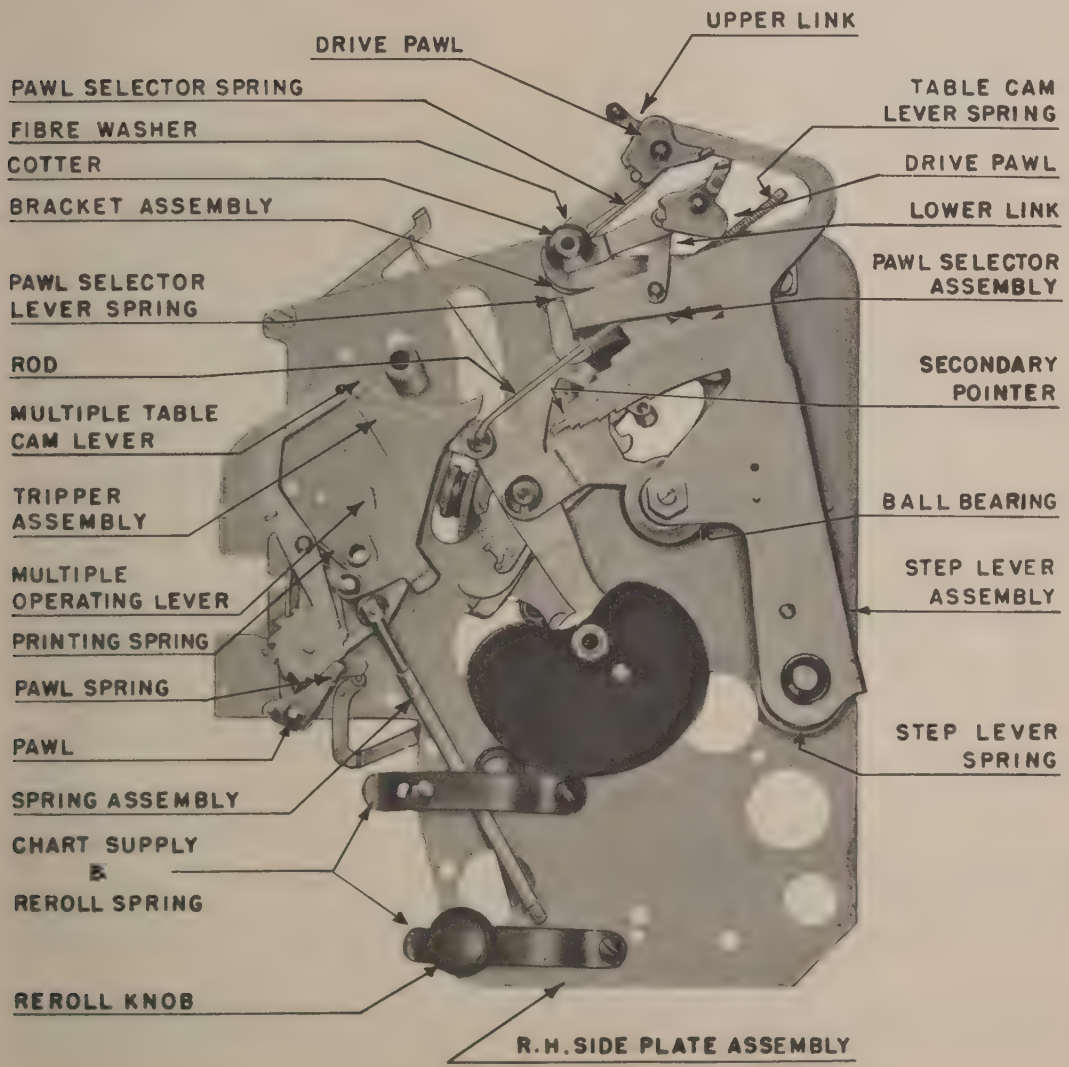


Fig. 1355-2 - Right-Hand Side Plate Mechanism of Multiple Record Print Hammer Instrument Large Gear and Ribbon Reel Removed

SECTION 1356
Issue 2

MECHANICAL OPERATION OF THE MULTIPLE POINT PRINT WHEEL POTENTIOMETER

The mechanical operation of the Print Wheel Instrument can be broken up into two parts: the balancing mechanism and the recording mechanism. These are described in detail as follows:

A. BALANCING MECHANISM

The balancing mechanism is the same as that which is described in the section, "Mechanical Operation of the Single Record Potentiometer".

B. RECORDING MECHANISM

The chart drive and print carriage drive is the same as on the single record recording mechanism.

The multiple record potentiometer with numeral print wheel produces records printed in colored numbers as follows:

No. of Records	SWITCH POINT NUMBER											
	1	2	3	4	5	6	7	8	9	10	11	12
2	Green	Red										
3	Green	Red	Purple									
4	Green	Red	Purple	Blue								
6	Green	Red	Purple	Blue	Black	Brown						
8	Green	Red	Purple	Blue	Black	Brown	Green	Red				
12	Green	Red	Purple	Blue	Black	Brown	Green	Red	Purple	Blue	Black	Brown

NOTE: 16 RECORD INSTRUMENTS CAN NOT BE FURNISHED TO PRODUCE MULTI-COLOR RECORDS

The records are produced in the form of a cross with a number alongside it, thus +4. The horizontal line of the cross represents the time co-ordinate, while the vertical line represents, the temperature co-ordinate. The intersection of the two represents a point on the time-temperature curve.

The print wheel rotates in a plane parallel with the temperature divisions on the chart. Any inaccuracy in the indexing (which is not likely) cannot affect the accuracy of the temperature record; it will merely introduce a slight error in the time record of the character being printed.

The numeral print wheel is illustrated in Fig. 1356-1. The recording mechanism is operated by a ratchet and gear, driven from the table cam lever through the ratchet operating link assembly. The printing cam has one position at which printing occurs and the Geneva gear is rotated by drive pins on the cam. The motion of the Geneva gear is transmitted to the left-hand side-plate assembly (shown in Fig. 1356-2). A gear on this shaft drives the thermocouple switch and the large idler gear which in turn drives the spline shaft.

The splined shaft drives the numeral print wheel and the ink pad wheel through spur gears in the print carriage assembly.

The print wheel carriage which is moved across the chart on the splined shaft by means of a spiral drive shaft, is carried entirely by the

splined shaft. There is a floating drive connection between the two shafts so that binding and friction cannot occur even if the two shafts are not parallel.

Backlash between the spiral drive shaft and the print carriage mechanism is taken up by means of a coil spring operating on a plunger in contact with the shaft. Any wear occurring is taken up equally in both directions against the slope of the thread.

The impression on the chart is made when the cam lever and guide bar assembly (Fig. 1356-2) drops in the depression of the printing cam, moving the print wheel by means of the guide bar. The correct printing pressure is applied by the printing spring.

The chart drum is made up of a metal tube with vulcanized rubber coating, similar to that used on typewriters, insuring accurate clear-cut printing, and silent operation.

Potentiometers having print wheels are supplied

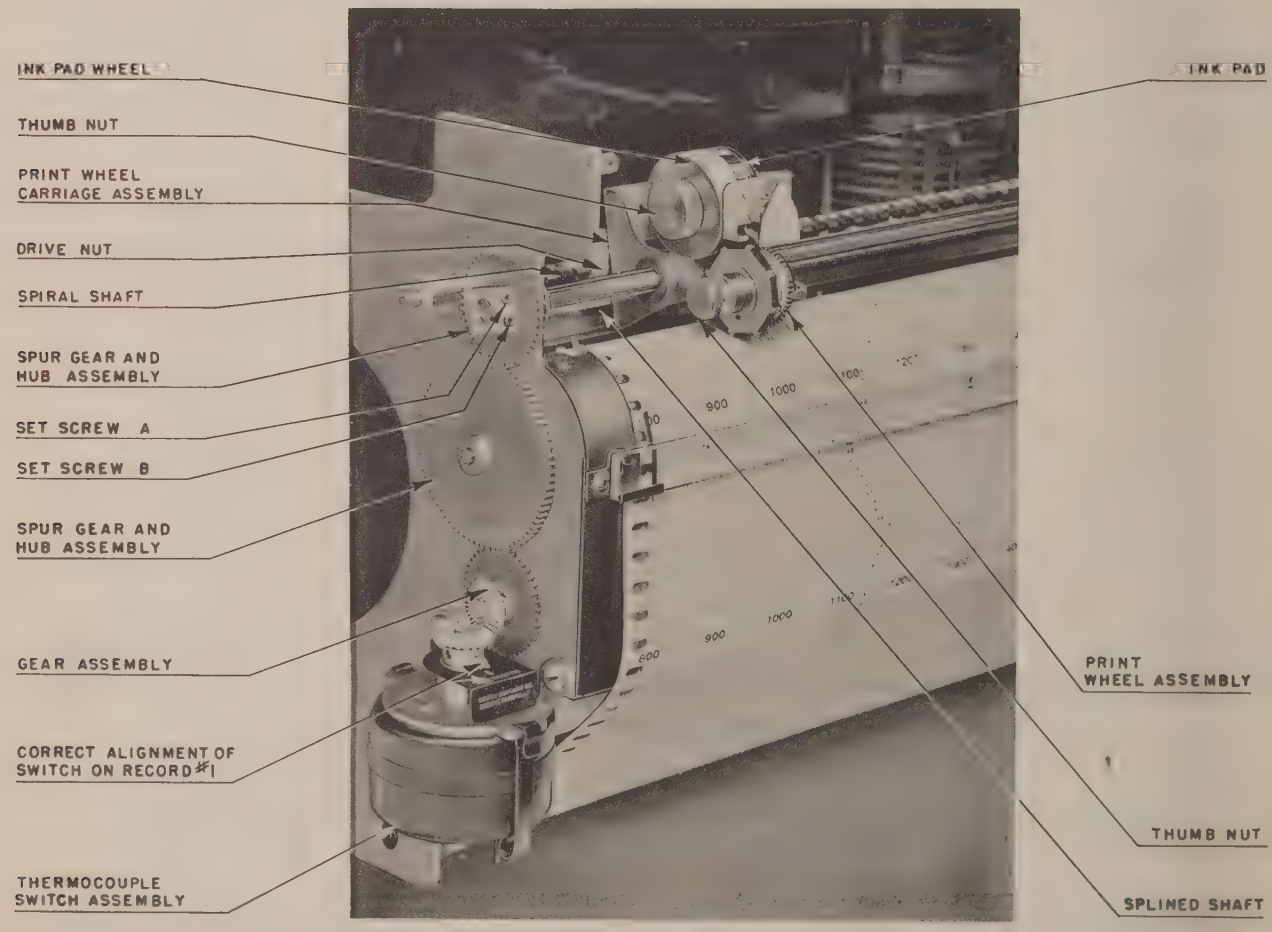


Figure 1356-1
Left-Hand Side Plate of Print Wheel Instrument
Showing Selector Switch and Printing Mechanism

in 3 styles: 1st, those printing numbers, representing the thermocouple, in one color ink; 2nd, those printing numbers in different colors of ink; and 3rd, those printing dots (no numbers) in different colors of ink.

Because the purple ink pad has a much longer life than any other color, it is used on instruments printing all records in a single color. This is felt to be a distinct advantage from the maintenance standpoint. As the purple ink pad wheel is interchangeable with the multi-color ink pad wheel, it is possible to change from one to the other in the field, if desired.

An arrow is provided on the right-hand chart clip to be used as a guide in setting the chart to the correct time.

The humidity compensator is not supplied because of space limitations. The chart has the elongated slots on the left-hand side, so that the effect of expansion and contraction of the chart through the normal operating range, is negligible.

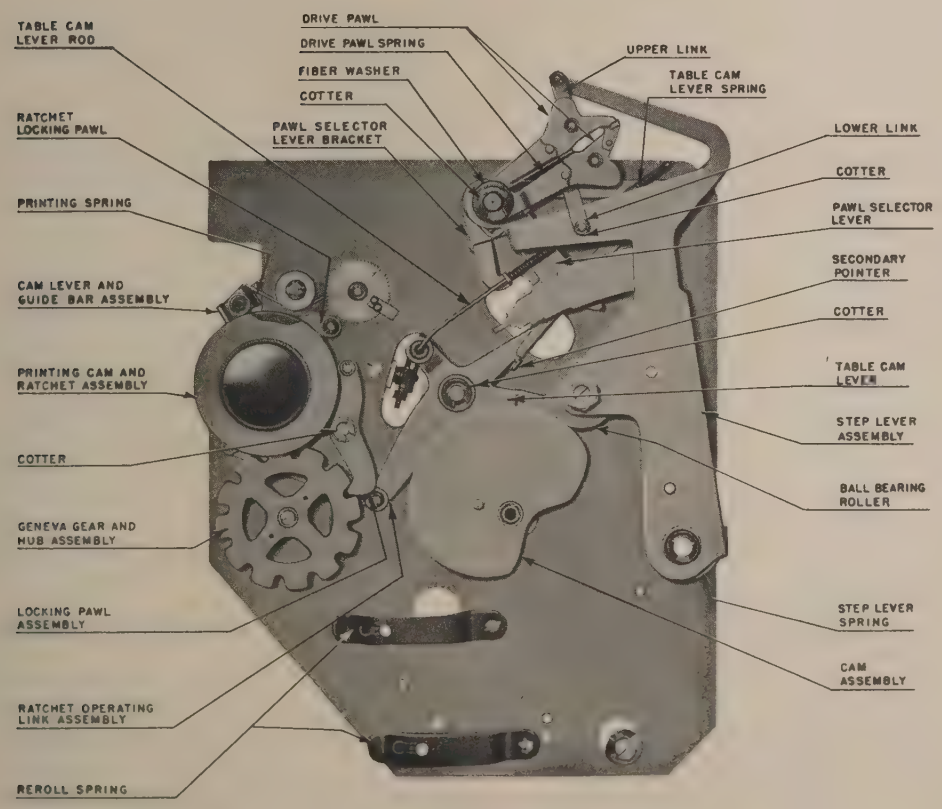


Figure 1356-2
Right-Hand Side Plate Mechanism Numeral
Print Wheel Instrument Spur Gear Removed

SECTION 1357
Issue 2

PRINCIPLES OF OPERATION OF THE CONTROL MECHANISMS

The most common of the control mechanisms used with the mechanical potentiometer are covered and are listed below:

A. Mercury Switch
B. Proportioning Control Mechanism
C. Program Control System
D. Air-O-Line Controller
E. Full Throttlor Controller
F. Beck Mechanism
G. ATC Mechanisms
H. Auxiliary Switch Mechanism
I. Interrupter Switch

A. MERCURY SWITCH CONTROL MECHANISM

The mercury switch control mechanism for the Single Record and Multiple Record Instruments are described separately.

The mercury switch is a hermetically sealed glass enclosure, usually cylindrical in shape, containing a quantity of mercury, and atmosphere of hydrogen gas or a vacuum, and either two or more electrodes, or provisions for dividing the mercury into separate pools. Due to its liquid nature and electrical conductivity, the mercury will make or break an electric circuit when the switch is tilted from the horizontal position. The mercury switches are used to operate relays controlling valve action or heater loads. If the load is small enough to be handled by the mercury switch, relays are eliminated, which reduces the amount of wiring and the danger of trouble from extra contacts, and eliminates all danger of corrosion at the contacts as well as danger of explosions in the presence of explosive vapors, fumes, etc. The mercury switches can be used to operate signal lights if desired, instead of a valve.

1. Single Record Mercury Switch Control

The application of an automatic control device to a process is usually a problem of controlling the supply of a medium in response to some measured change of conditions in the process itself. The control instrument then changes the position of the control device, a valve for example, when the demand of the process itself requires such a change, which is indicated by the position of the pen with respect to the control index. The selection of the proper type of control should be based primarily upon what operating characteristics appear most desirable for the specific application.

Automatic operation of valves, relays, or power switching is accomplished through mercury switches located in the lower part of the back of the instrument. From one to three switches may be provided, depending on the type of control device to be operated.

The switches are operated by power delivered directly from the motor through the table cam. The selection of the proper switch is done by the control mechanism. On each revolution of the table cam, the control cam lever and control arm move the switch finger carrier to the left or rear of the instrument. The control lever link raises the switch finger carrier into position so that the proper switch finger contacts the proper switch arm and tips a switch in order to make or break a circuit (see Fig. 1357-1). A control knob on the outside left-hand side of the case connects through a shaft and gears to another spiral shaft, similar to the spiral pen shaft, which drives the control carriage. To set the control, it is necessary only to push in and turn the knurled knob above the door knob. Care should be taken that the knob is turned only when the control bar and table are in the UP position. The control setting may be locked by removing the control setter knob. This can be done by loosening the small screw on the control setter shaft bushing, inside the door.

The control carriage has a control step table mounted on its underside which positions a control bar, mounted parallel to and behind the scale. The number of steps on the control table determines whether the type of control is on-off, 2-position, or 3-position, which determines whether 1, 2, or 3 mercury switches are required, respectively. The control bar connects to and operates the control lever link, which positions the switch finger carrier on which the proper switch fingers are placed.

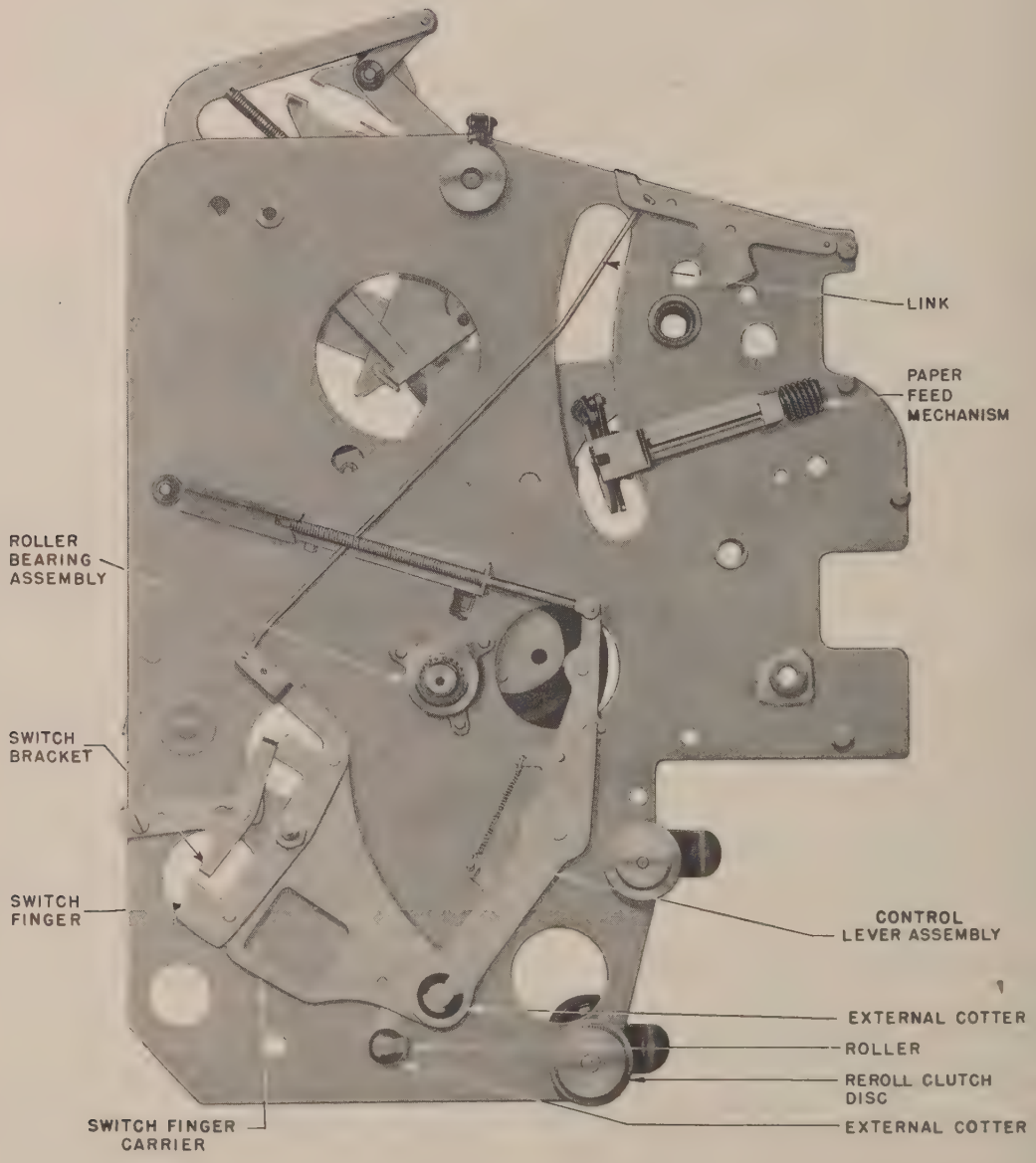
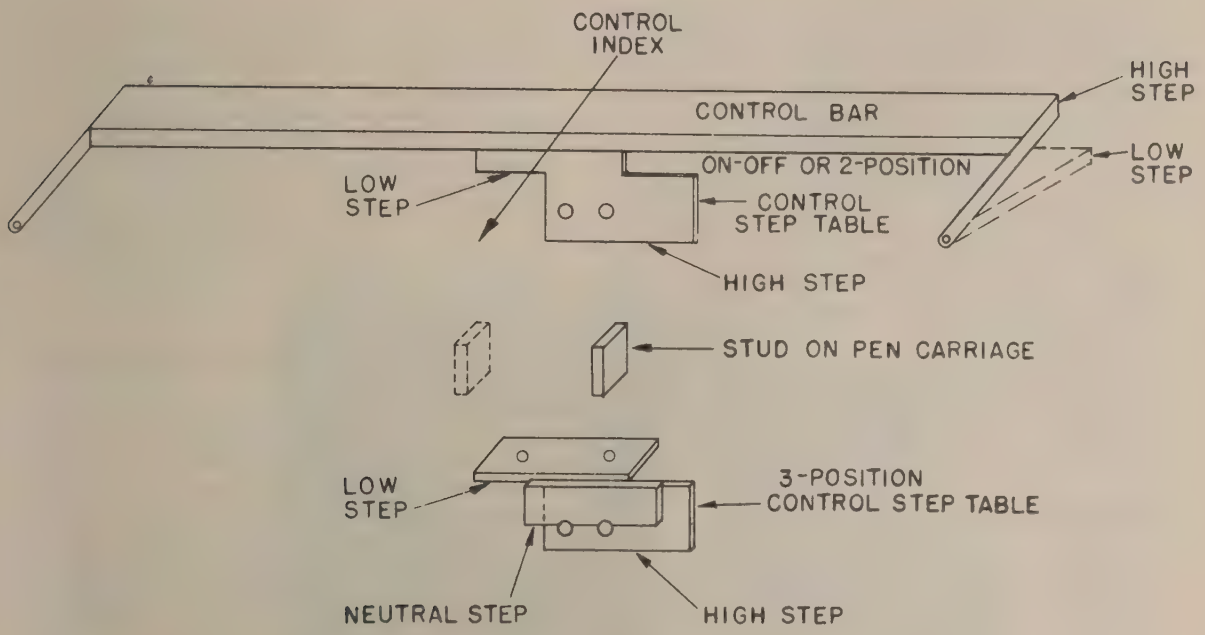


Figure 1357-1
Single Type Switch Control Mechanism
View of Inside of Right-Hand Side Plate



Drawing 16-G-07
Schematic Drawing Showing Control Step Tables and Control Bar Positions

a. On-Off Control

The on-off type of control uses one single-pole single-throw mercury switch. When the pen is below the control point, the current is turned on through the mercury switch. This energizes the motor on the control valve so that the valve opens to a definite adjustable stop. The valve stays open until the pen comes up to the control index, whereupon the switch is tipped so that the circuit through it is broken and the valve is closed by spring action.

On an electric furnace load, the circuit to the furnace or to a relay is made when the pen is below the control point and broken when the pen gets to the control point.

b. 2-Position Control

The 2-position type of control uses two single-pole single-throw mercury switches and differs from the on-off type in that, when the pen reaches the control temperature, the first switch tips off and the second switch tips on and the circuit is made through the second switch. This type of control is used on a motor valve requiring power rather than a spring to close the valve. Both on-off and 2-position control regulate the fuel supply so that it is either full-on or full-off.

The principal limitation of these two types of control mechanisms, on many applications, is the sudden change in quantity of the controlled medium. This action would be particularly undesirable in some furnace controls where a large movement of the valve would produce an appreciable change in the flame. In order to reduce the surges and to avoid large swings in the temperature, particularly on those applications where the time lag is appreciable, the movement of the valve can be reduced by adjusting the limit switches so that a movement of the valve mechanism from one limit position to another will cause only a small change in the flow of fuel to the burners.

This reduction in the amount of valve movement tends to reduce the surges and the resulting temperature control record will show a saw-tooth line of fairly small amplitude. Such an arrangement might be satisfactory under conditions where the fuel pressure and the demand on the furnace are quite steady, but a change of pressure in the fuel line or a change in the furnace load will probably require a readjustment of the valve limit positions corresponding to the two positions of the operating mechanism. For example, the mechanical connection between the motor mechanism and the valve might be changed so that the valve would operate between one-

half and two-thirds open instead of between one-third and one-half open. The control mechanism necessarily requires a valve adjustment which allows less than the required amount of controlled medium to flow when in a closed position and allows an excess to flow when the valve is in an open position. It follows, therefore, that the valve mechanism can never remain at rest for any length of time. It can never stop in the correct position but must periodically move back and forth. This inherent limitation suggests a modification; to add a third position which would be substantially what is necessary to provide a correct flow of the controlled medium at the desired operating temperature. This modification requires the control instrument to have three control contacts in place of the usual high and low contact.

c. 3-Position Control

The 3-position type of control uses three single-pole single-throw mercury switches and these switches are operated mechanically so that one of the three is tipped and a circuit made through it, depending on whether the pen is below, at, or above the control index. The operating range of the control valve itself is increased by virtue of this middle or neutral position. The valve movement from the middle to the low position or from the middle to the high position can be the equivalent of the full stroke of an on-off or a 2-position mechanism with the result that the total range of valve movement has been doubled.

d. Mechanical Operation

The control table on the control carriage limits the depression of the control bar. The control table has a step, or steps, which contact a stud on the pen carriage. This limits the downward motion of the control table and consequently the control bar. At every cycle, the control bar is lifted to its highest position and descends as low as the stud on the pen carriage will allow it. As the pen carriage approaches, reaches, and passes the control point, the stud on the pen carriage contacts first the low step, then the neutral step, and next the high step of the control table. Therefore, the step in the control table governs the position of the control bar and control arm to two or three definite stopping places, depending upon the type of control. Any change in temperature indicated by a movement of the pen carriage is transmitted by means of the control bar and control link to the switch finger carrier. The position of the control bar governs the position of the switch finger carrier. The switch finger carrier is designed so that at each of its positions, different levers of the switch assembly are moved. The movement of the switch finger carrier, which moves the mercury switches, is obtained when the control lever assembly, rolling on a positioning roller located on the lower inside part of the side plate, is driven by the table cam on the main drive shaft.

2. Multiple Record Mercury Switch Controller

In a multiple record controller, the switch selections are controlled by means of a switch finger selector lever, Fig. 1357-2, so that only one switch will be operated from a specific thermocouple. The switch finger selector lever contacts with the color selector cam (which selects the color that the instrument prints) and this contact determines the selection of the proper switch for a particular record. The position which is selected by the selector lever holds one or two switch fingers in a high, inoperative position, and allows one to drop into an operative position. The entire switch finger carrier assembly is then raised or lowered to cause the proper switch action which has been determined by the control table. Except for the switch finger selector lever, the action is similar to the single record controller.

Multiple record controllers are designed to control 1, 2, or 3 records at the same temperature, or two records at different temperatures. In the first case, the type of control applied to all records can be either on-off, 2-position, or 3-position.

In the second case, the type of control applied to both records can be either on-off or 2-position, never 3-position. With an instrument of this type, two control carriages are used, the right-hand carriage being positioned by the control setting knob above the door knob. The left-hand carriage is connected through a link with the right-hand carriage. The link has a slot and the left-hand carriage can be set to any distance within the length of the slot away from the right-hand carriage, by pushing or pulling the left-hand carriage with the right-hand carriage.

Either control carriage can be fastened at any position on the scale by tightening the tall thumb screw (one for each carriage) showing above the scale.

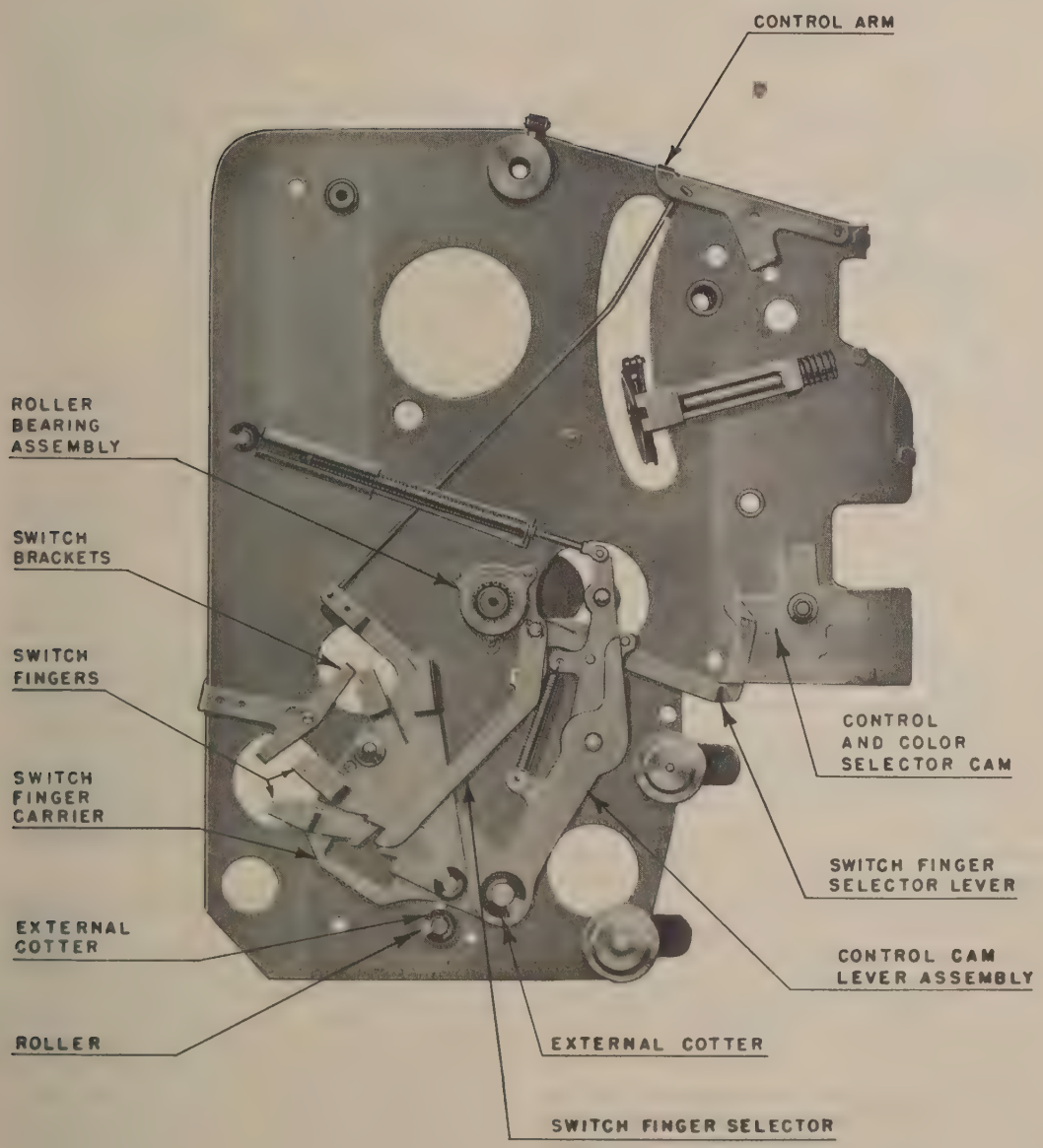


Figure 1357-2
Multiple Type Switch Control Mechanism
View of Inside of Right-Hand Side Plate

The three steps available for 3-position control at the same temperature point are split up so that the low and neutral step apply to the lower control temperature point, while the neutral and high step apply to the higher temperature control point. The same neutral step is used as high for one temperature and low for the other. This selection is accomplished by the switch finger selector lever.

Multiple controlling instruments are supplied in various combinations. An instrument may record on one or more points and control on one record only. These controllers have special mechanisms to hold the switch fingers inoperative while the instrument is recording on the temperatures which are not being controlled. All instruments of this type are furnished with special instructions.

The maximum control setting on single or multiple record control instruments using mercury switches is 3/4" below the full scale pen position. This is a constructional limit.

B. SINGLE RECORD PROPORTIONING CONTROL

A further development is the "proportioning system" of control, which uses an electromechanical method for securing modulation of motion of the valve by utilizing a standard alternating current supply circuit. This system provides a number of steps between full-open and full-closed valve position. The high-low control temperature limits are spanned by a wire wound resistance of 135 ohms, the extremities of which are connected to two wires of the control circuit. A sliding contact, which takes its position from the relation of the pen with respect to the control temperature, is connected to the third wire, hence dividing the resistance into two arms. As this contact is moved over the resistance, it varies the ratio of the two arms of the electrical transmission system, essentially a Wheatstone bridge. Hence, there is no waiting for the making of a high, low, or neutral or some other definite control circuit before a reaction occurs at the motor driven device.

To describe the operation, first assume that the pen is at the control index and the sliding contacts in all the units shown are in a balanced position as shown in Dwg. 16-G-08, which is a diagrammatic presentation of the circuits of the proportioning system that incorporates the three separate elements, namely, the control instrument or potentiometer, the transformer, and the power or motor unit which houses the balancing relay.

Under these conditions, the resistances HC, CL, BR and RW are balanced and the current flowing in coil C_1 is equivalent to that flowing in coil C_2. The armature will then be acted upon by equal magnetic forces from coils C_1 and C_2 and the blade will be held in the center of the gap between the two relay contacts. The motor will be at rest when the relay armature is in this center position.

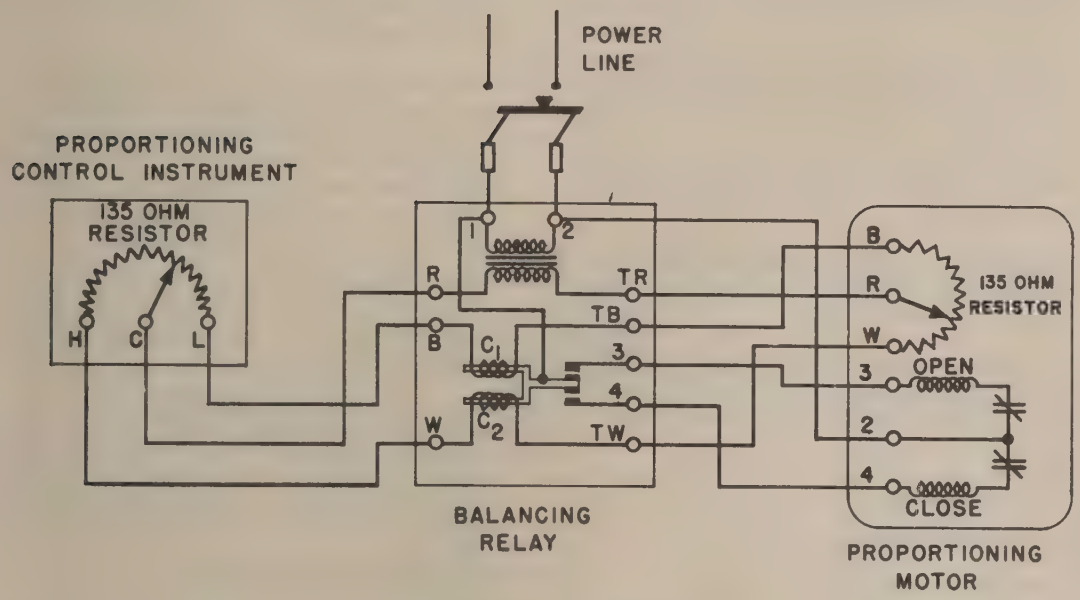
Any deflection of the pen away from the control index will unbalance the bridge. Assuming that this moves the contact C toward the extremity H there will be an immediate unbalance in the electrical system as the resistance HC + RW will be less than CL + BR. The net result is that more current will flow in the circuit of coil C_2 than in that of C_1. The armature will then move toward coil C_2 due to the increased magnetic effect and the blade will make with contact #4.

With this circuit closed the motor will tend to close the control valve and at the same time the sliding contact R on the resistor in the proportioning motor will move toward B until the bridge circuit is rebalanced. When this rebalance occurs, equal currents flow through the coils C_1 and C_2 and the relay blade returns to the center of the gap between contacts 3 and 4, stopping the proportioning motor.

It is evident that when the relay is in its central position, the motor unit in bringing it to that balance has rotated an amount which is proportional to the deflection of the primary controlling device. From this particular feature is derived the name "proportioning control", defined as an equality of ratios. A very important feature in the operation of this system is that the reversing motor elements within the power unit operate only when a change of position is demanded by the controller.

The slope of the control table on the control carriage is designed to give full-open to full-closed valve position for a pen movement of 2.4 to 6% of the full scale pen movement (called throttling range) in four adjustable steps of 2.4, 3.6, 4.8, and 6.0%. A throttling range of 4 to 10% having steps of 4, 6, 8, and 10%, or a range of 1.1 to 2.0% with steps of 1.1, 1.4, 1.7, and 2.0% can be supplied. The maximum control setting for the proportioning controller is 1-1/2" below the full scale pen position.

A feature of the proportioning control which has not been covered is the number of resistors which can be used with a single pen. There is enough space in the mercury switch compartment to insert four resistors. Each of these resistors is connected to its own valve mechanism.



Drawing 16-G-08
Schematic Wiring Diagram
Proportioning Control Systems

Accordingly, one thermocouple can control the position of one to four proportioning motor-operated valves. The arrangement for two temperatures is similar, and one, two, or three resistors can be operated from one thermocouple while the remaining resistor or resistors are operated from another thermocouple. When positioning the contacts on the resistors, they can be offset so that all the valves do not open to the same point for a definite pen position in relation to the control point.

1. Multiple Record Proportioning Control

Proportioning controllers are supplied for multiple record instruments. The number of recorded points is limited to 5. One or two records can be controlled at the same or at different temperatures. When one record in five is to be controlled, a six-segment oil switch is used, on which the fifth segment records the control temperature and the control is operated when the sixth segment is moved in contact after the fifth point has balanced. For controlling one record in four, a six-segment switch is also used. The instrument records points 1, 2, 3, and 4, which is the controlled record. No. 5 and No. 6 segments are connected to control the No. 4 record. To control one record in three, a four-segment switch is used in which the fourth segment controls the No. 3 record after No. 3 has balanced and printed. In all the above cases, a mercury switch is placed on the left-hand side plate of the instrument to break the power circuit to the relay so that the control circuit will function only when the control segment is in contact. When two records are controlled at two different temperatures, the instrument has two control tables, two control bars, and two control contacts on two different resistors. There is also a mercury switch, single-pole double-throw, mounted on the left-hand side plate, to break the electrical control circuit except when the control segment for the controlled record is connected.

C. THE PROGRAM CONTROL SYSTEM

The Brown Program Control System consists essentially of a Potentiometer Pyrometer on which is installed a means of moving the control index up and down scale at a predetermined rate. Moving this index at a certain time rate and in a desired direction produces a cycle of heating or cooling which is called a program.

The program control system provides the following functions in addition to the usual control features:

1. A predetermined heating rate from one point to another predetermined point on scale or chart.

2. A holding or "soaking" period of predetermined length during which the control index remains stationary.

3. A predetermined cooling rate from one predetermined point to another p cint on the scale or chart.

Depending upon the individual design of the circuit the above functions may be combined in an almost infinite number of ways.

For a reference to the particular application, refer to the wiring diagram which accompanies the shipment. This diagram includes the following information.

1. Actual connection between all equipment

2. Graph of the desired program

3. Schematic wiring diagram

4. Sketch of the operation of the circuit

Various auxiliary equipment is used to accomplish the control actions of the program control system. A rate controller is used in series with the windings of the control point drive motor in order to adjust the rate of downscale or upscale drive.

A soaking time controller is used to time the length of the holding or "soaking" periods and is sometimes used to time the rate of upscale or downscale drive.

All throughout the program the temperature is controlled through the usual control circuit of the potentiometer.

1. Description of the Program Equipment

After the installation of the Program Control System has been completed, the schematic wiring illustrated on the wiring diagram which accompanies these instructions should be carefully reviewed in order to ascertain the operation of the control system.

a. Control Point Drive Mechanism

The motor drive for control point setting consists of a small reversible synchronous motor which is used to drive an adjustable gear train. It is supplied on potentiometer type instruments, and is mounted near the left-hand sideplate by means of two screws which are screwed into tapped holes in the instrument frame.

The connections to the motor are shown on the internal wiring diagram of the controller, which is listed on the external diagram, and furnished upon request. As its name implies, the mechanism drives the control index either upscale or downscale, depending on which winding of the motor is energized.

The Drawing 16-G-09 illustrates the 1/2"-1/16" per minute control point drive. It is important to note that only this drive has a speed change.

All other control point drives are set for only one speed. These drives might be of the following speeds - 2.77, 1.385, .948, or .474 inches per hour. Referring to your particular order will give the speed of the particular drive.

b. Auxiliary Switch Mechanism

The auxiliary switch mechanism may be mounted on either the right-hand sideplate or left-hand sideplate of the instrument chassis. The mechanism may have either one or two single throw mercury switches. Therefore, the contact operation may be either SPST, or SPDT, or DPST.

The switch mechanism may be driven from either the control shaft or the pen shaft; in other words, operated from the position of the pen, or the position of the control index.

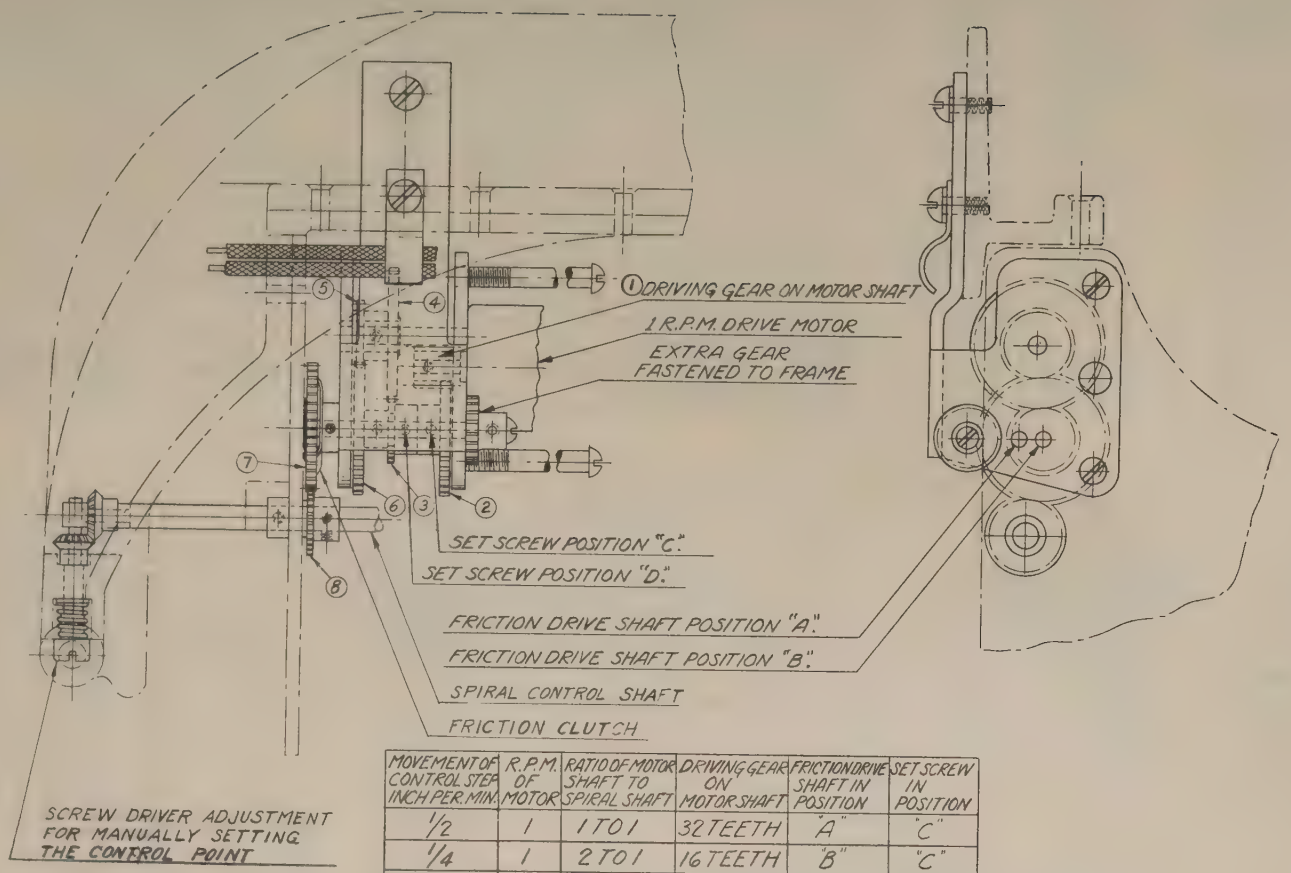
For program control systems, the auxiliary switch mechanism will usually be operated from the control index.

The switch is tilted when two slotted discs, driven by gears from the pen or control shaft, come in alignment.

c. Soaking Time Controller

Except in unusual cases, the soaking time controller used in the program control system will be an Automatic Temperature Control Company vernier set timer.

Never under any circumstances should the electrical arrangement of the soaking time controller be altered by moving the jumpers X, Y, or Z on the terminal block or by moving the red, yellow, or green slides because this will prevent the program from following the desired sequence.


① DRIVING GEAR ON MOTOR SHAFT
1 R.P.M. DRIVE MOTOR
EXTRA GEAR FASTENED TO FRAME
SET SCREW POSITION "C".
SET SCREW POSITION "D".
FRICTION DRIVE SHAFT POSITION "A".
FRICTION DRIVE SHAFT POSITION "B".
SPIRAL CONTROL SHAFT
FRICTION CLUTCH
SCREW DRIVER ADJUSTMENT FOR MANUALLY SETTING THE CONTROL POINT

MOVEMENT OF CONTROL STEP INCH PER MIN.	R.P.M. OF MOTOR	RATIO OF MOTOR SHAFT TO SPIRAL SHAFT	DRIVING GEAR ON MOTOR SHAFT	FRICTION DRIVE SHAFT IN POSITION	SET SCREW IN POSITION
1/2	1	1 TO 1	32 TEETH	"A"	"C"
1/4	1	2 TO 1	16 TEETH	"B"	"C"
1/8	1	4 TO 1	32 TEETH	"A"	"D"
1/16	1	8 TO 1	16 TEETH	"B"	"D"

MOTOR DRIVE FOR POTENTIOMETER CONTROL SETTING

The soaking time controller requires a contact to energize the timing mechanism. The mechanism then makes a contact during, and another contact after timing. These contacts are used to further the program sequence.

d. Rate Controller

Except in unusual cases, the rate controllers used in the program control system will be an Automatic Temperature Control Company current input controller.

In most cases the dial of the rate controller is calibrated directly in terms of temperature rise or fall per hour (degrees per hour).

The rate controller makes a contact for the percentage of time indicated on the dial. The rate controller has an adjustable contact closure of 0-100% and has a dial calibrated 0-100%. Therefore, if the dial setting is 70% the contact is made 70% of a certain period and broken for 30% of the same period.

When specified, the rate controller can be supplied with an adjustable contact closure of 0-40% and with a dial calibrated 0-100%. Therefore, if the dial is set at 70%, the contact is closed 70% times 40%, or 28% of the period.

Reference to your particular order will show whether the rate controller has an adjustable contact closure of 0-100% or 0-40%. If no specification is given on the order, the contact closure will be the standard 0-100%.

e. Auxiliary Equipment

Other equipment such as relays, push buttons, etc. do not require any adjustments.

D. THE BROWN AIR-O-LINE CONTROLLER

The Brown Air-O-Line Potentiometer Controller is the air operated instrument which contains full throttling and automatic reset mechanisms. This instrument has an adjustable throttling range from on-off operation up to 150% and a full range of automatic reset rates. The element used for measuring temperatures may be either a thermocouple or resistance thermometer bulb.

1. Principle of Operation of the Brown Air-O-Line

Dwg. 10-G-93 shows a schematic diagram of the Brown Air-O-Line Potentiometer Controller, applied to a steam heated tank. The temperature in tank (31) is measured by thermocouple (32), and controlled by the steam flow through valve (9).

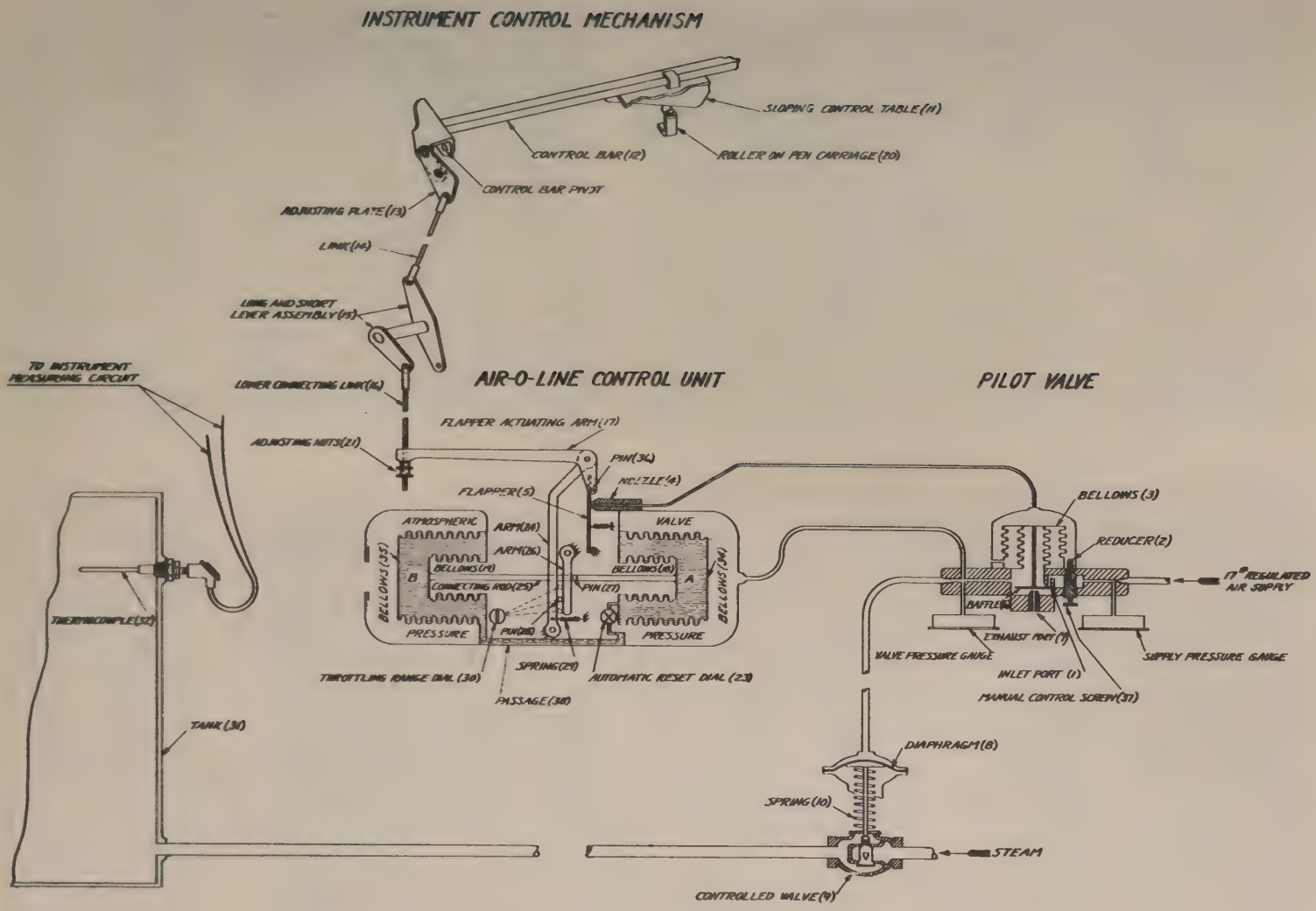
a. Pilot Valve

A schematic diagram of the pilot valve is shown on the right side of Dwg. 47-S-76-E. This pilot valve is of the multiplying type, that is, it multiplies changes in the nozzle pressure to give the resultant valve pressures. The function of the pilot valve is to utilize the comparatively low pressure in the nozzle system to operate larger ports which rapidly admit air to and from the diaphragm valve.

An external regulator applies air at 17 lbs. to inlet port (1), and through reducer (2) to bellows (3) and nozzle (4). Reducer (2) is smaller than nozzle (4) so that when flapper (5) is off nozzle (4), there is no pressure on bellows (3) which causes baffle (6) to cover inlet port (1) and to uncover exhaust port (7). This exhausts the air from controlled valve diaphragm (8) and permits spring (10) to close controlled valve (9). When flapper (5) covers nozzle (4), the air through reducer (2) increases the pressure on bellows (3) which moves baffle (6) to uncover inlet port (1) and cover exhaust port (7), increasing the pressure on controlled valve diaphragm (8) which opens controlled valve (9) against the force of spring (10).

b. Control Index Setting Mechanism

The pen carriage, equipped with a special split nut bearing, has a roller (20) which contacts a sloping control table (11). The sloping control table is fastened to the control carriage. To set the control carriage at the desired temperature, it is necessary only to push in and turn the knurled knob above the door knob. The sloping control table (11) also is fastened to the control bar (12), which is raised and lowered by the roller (20) on the pen carriage, depending on the position of the recording pen in relation to the control point. The motion of this bar (12) is transmitted by the upper connecting link (14) to the extension, toward the rear of the case of the long arm in a long and short lever assembly (15). The short arm of this long and short lever assembly, through lower connecting link (16), operates flapper actuating arm (17).



Dwg. 10-G-93 - Schematic Drawing
Potentiometer Air-O-Line Controller

With the recording pen at the control point, through the linkage described above, the flapper actuating arm (17), lets flapper (5) just touch nozzle (4), when arm (24) is in the vertical position shown. If the temperature rises and moves the pen upscale from the index only slightly, control bar (12) is moved upward which, through the linkage, rotates flapper actuating arm (17) clockwise. This slight motion lifts flapper (5) from nozzle (4), which operates the pilot valve and exhausts air from the controlled valve (9). The slightest downscale pen movement from the index, through the same levers, rotates flapper actuating arm (17) counter-clockwise and lets flapper (5) cover nozzle (4). This operates the pilot valve and admits air to the controlled valve (9). Likewise, if the pen were stationary, and the index setting were moved away from the pen, similar motion would be transmitted to the flapper actuating arm (17) to operate the controlled valve (9).

By simply connecting the upper connecting link (14) to the opposite extension of the long arm (15), the opposite motion is transmitted to the operating pin (36), so that by these connections to the long arm (15), the flapper actuating arm (17) may be made to either increase or decrease the pressure to the diaphragm valve (9), with decrease of temperature.

c. Air-O-Line Control Unit

The primary function of the Air-O-Line control unit is to provide a means of governing the valve pressure change resulting from a given pen movement. This unit is interposed between the action of the pen, (or other measuring element) on the flapper, and the pilot valve. Without this unit, the pen would operate the flapper and the pilot valve to produce on-off control action; i.e., any slight separation of the pen and the index would cause the controlled valve to either completely open or close. "Throttling" or "Proportioning" action is produced as follows:

d. Throttling Action

If the temperature decreases, moving the pen downscale causes the flapper actuating arm (17) to rotate counter-clockwise, which allows flapper (5) to cover nozzle (4). The air flow through reducer (2) then increases the pressure on bellows (3) which moves baffle (6) off inlet port (1) and towards exhaust port (7), increasing the controlled valve pressure, admitting more steam. The controlled valve pressure simultaneously acts upon bellows (18). As bellows (18) is compressed, its motion through rod (25) and pin (27) is transmitted to reset arm (26) and, in turn, to pin (28) on arm (24) which carries flapper actuating arm (17) moving flapper (5) away from nozzle (4). Therefore, flapper (5) is moved away from nozzle (4) nearly the full distance the pen moves it toward nozzle (4).

The distance the bellows pushes flapper (5) back off nozzle (4) is governed by the distance flapper actuating arm (17) is moved by bellows (34) which distance, in turn, is governed by the position of pin (28). For a given downscale pen movement, there is secured a net flapper movement and a net controlled valve pressure change, dependent upon the position of pin (28). Therefore, for a given position of pin (28), there is a definite flapper position and a definite controlled valve pressure for each pen position. This proportionality between pen movement and resultant controlled valve pressure change, is known as "Throttling Range". Throttling range is expressed as the percent of full scale pen movement required to change the controlled valve pressure from 0 to 15 lbs. The position of pin (28), or the Throttling Range, is adjusted by turning throttling range dial (30).

It will be noted that the demand for more steam caused the pen to move downscale, which resulted in a wider opening of the controlled valve. This increased valve opening varies directly with the distance the pen moves below the index. The greater the demand for more steam, the farther the pen must move downscale from the index to obtain this increased steam flow. Since there is a definite controlled valve pressure for each pen position, the increased steam flow can be obtained only as long as the pen remains below the control index; a distance corresponding to the increased steam demand. If the pen is to be returned to the desired temperature, it is necessary to increase the controlled valve pressure and admit more steam than has resulted from this downscale pen movement. This requires that the flapper moves nearer the nozzle. This can be done mechanically by setting the control index upscale, which, through the linkage, rotates flapper actuating arm counter-clockwise. Of course, the control index is then no longer at the controlled temperature. A similar movement of the flapper toward the nozzle without resetting the index is accomplished automatically in the Brown Air-O-Line Unit.

e. Automatic Reset

An increase in the controlled valve pressure increases the pressure on liquid (A) between bellows (34) and (18). The liquid then flows from space (A) through the needle valve, adjusted by automatic reset dial (23) and passage (38), to space (B), causing connecting rod (25), carrying pin (27), to move to the right. Spring (29) causes arm (24) and flapper actuating arm to follow. This moves flapper (5) toward nozzle (4) increasing the controlled valve pressure. The rate at which flapper (5) is moved, and the controlled valve pressure is increased, depends upon the rate at which the liquid flows from (A) to (B), or upon the pressure difference between (A) and (B), which depends upon the distance of the pen below the control index.

The controlled valve pressure increases, admitting more steam and raising the temperatures in tank (31). As the pen moves upscale, the pressure difference between (A) and (B) decreases until they are at equal pressures, at which point the pen will coincide with the control index. There is no further increase in controlled valve pressure. The controlled valve has been opened to supply enough steam to restore the temperature to the control point.

It is important to note that after such a pen departure, if the pen returned upscale abnormally fast, the control bar (12) moves the flapper actuating arm (17) so as to lift flapper (5) faster than the reset liquid displacement moves flapper actuating arm (17) to let flapper (5) cover nozzle (4), with the result that the valve pressure is decreased as the pen approaches the control index. By the same means, if the pen moves upscale abnormally slowly, the liquid displacement from (A) to (B) causes flapper (5) to cover nozzle (4), increasing the valve pressure further. Therefore, the Air-O-Line unit, by means of its Throttling Range and Automatic Reset, recognizes the amount of departure, and the rate at which the pen moves, and makes corrections accordingly.

By similar upscale pen movement, lower valve pressures may be established to reduce steam flows sufficiently to maintain the pen at the control index.

E. THE BROWN FULL THROTTLER CONTROLLER

The Brown Full Throttler Potentiometer Controller is the air operated instrument which contains full throttling and manual reset mechanisms. This instrument has an adjustable throttling range from on-off operation up to 150 per cent and a full range of manual reset points. The element used for measuring temperatures may be either a thermocouple or resistance thermometer bulb.

1. Principle of Operation of the Brown Full Throttler

Drawing 16-G-11 shows a schematic diagram of the Brown Full Throttler Potentiometer Controller, applied to a steam heated tank. The temperature in tank (31) is measured by thermocouple (32), and controlled by the steam flow through valve (9).

a. Pilot Valve

A schematic diagram of the pilot valve is shown on the right side of Figure 16-G-11. This pilot valve is of the multiplying type, that is, it multiplies changes in the nozzle pressure to give the resultant valve pressures. The function of the pilot valve is to utilize the comparatively low pressure in the nozzle system to operate larger ports which rapidly admit air to and from the diaphragm valve.

An external regulator applies air at 17 lbs. to inlet port (1), and through reducer (2) to bellows (3) and nozzle (4). Reducer (2) is smaller than nozzle (4) so that when flapper (5) is off nozzle (4), there is no pressure on bellows (3) which causes baffle (6) to cover inlet port (1) and to uncover exhaust port (7). This exhausts the air from controlled valve diaphragm (8) and permits spring (10) to close controlled valve (9). When flapper (5) covers nozzle (4), the air through reducer (2) increases the pressure on bellows (3) which moves baffle (6) to uncover inlet port (1) and cover exhaust port (7), increasing the pressure on controlled valve diaphragm (8) which opens controlled valve (9) against the force of spring (10).

b. Control Index Setting Mechanism

The pen carriage, equipped with a special split nut bearing, has a roller (20) which contacts a sloping control table (11). The sloping control table is fastened to the control carriage. To set the control carriage at the desired temperature, it is necessary only to push in and turn the knurled knob above the door knob. The sloping control table (11) also is fastened to the control bar (12), which is raised and lowered by the

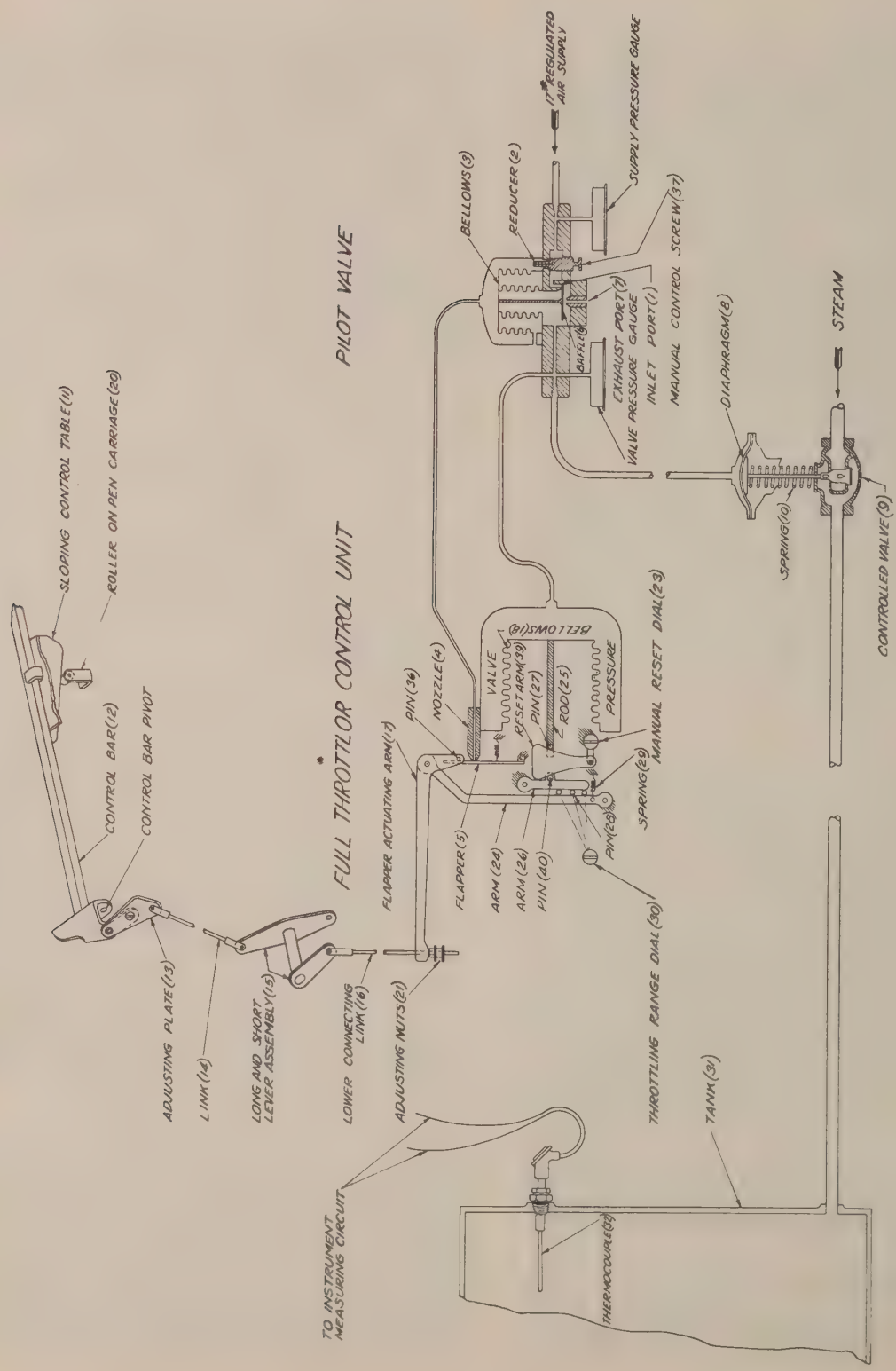


Fig. 16-G-11

POTENTIOMETER FULL THROTTLOR CONTROLLER

roller (20) on the pen carriage, depending on the position of the recording pen in relation to the control point. The motion of this bar (12) is transmitted by the upper connecting link (14) to the extension, toward the rear of the case, of the long arm in a long and short lever assembly (15). The short arm of this long and short lever assembly, through lower connecting link (16), operates flapper actuating arm (17).

With the recording pen at the control point, through the linkage described above, the flapper actuating arm (17), lets flapper (5) just touch nozzle (4), when arm (24) is in the vertical position shown. If the temperature rises and moves the pen upscale from the index only slightly, control bar (12) is moved upward which, through the linkage, rotates flapper actuating arm (17) clockwise. This slight motion lifts flapper (5) from nozzle (4), which operates the pilot valve and exhausts air from the controlled valve (9). The slightest downscale pen movement from the index, through the same levers, rotates flapper actuating arm (17) counter-clockwise and lets flapper (5) cover nozzle (4). This operates the pilot valve and admits air to the controlled valve (9). Likewise, if the pen were stationary, and the index setting were moved away from the pen, similar motion would be transmitted to the flapper actuating arm (17) to operate the controlled valve (9).

By simply connecting the upper connecting link (14) to the opposite extension of the long arm (15), the opposite motion is transmitted to the operating pin (36), so that by these connections to the long arm (15), the flapper actuating arm (17) may be made to either increase or decrease the pressure to the diaphragm valve (9), with decrease of temperature.

c. Full Throttlor Control Unit

The primary function of the Full Throttlor Control Unit is to provide a means of governing the valve pressure change resulting from a given pen movement. This unit is interposed between the action of the pen, (or other measuring element) on the flapper, and the pilot valve. Without this unit, the pen would operate the flapper and the pilot valve to produce on-off control action; i.e., any slight separation of the pen and the index would cause the controlled valve to either completely open or close. "Throttling" or "Proportioning" action is produced as follows:

d. Throttling Action

If the temperature decreases, moving the pen downscale causing the flapper actuating arm (17) to rotate counter-clockwise, which allows flapper (5) to cover nozzle (4) the air flow through reducer (2) then increases the pressure on bellows (3) which moves baffle (6) off inlet port (1) and towards exhaust port (7), increasing the controlled valve pressure, admitting more steam. The controlled valve pressure simultaneously acts upon bellows (18). As bellows (18) is compressed, its motion through rod (25) and pin (27) is transmitted to reset arm (39) and, in turn, to pin (40) on arm (26) and through pin (28) to arm (24), which carries flapper actuating arm (17) moving flapper (5) away from nozzle (4) Therefore, flapper (5) is moved away from nozzle (4) nearly the full distance the pen moves it toward nozzle (4).

The distance the bellows pushes flapper (5) back off nozzle (4) is governed by the distance flapper actuating arm (17) is moved by bellows (18) which distance, in turn, is governed by the position of pin (28). For a given downscale pen movement, there is secured a net flapper movement and a net controlled valve pressure change, dependent upon the position of pin (28). Therefore, for a given position of pin (28), there is a definite flapper position and a definite controlled valve pressure for each pen position. This proportionality between pen movement and resultant controlled valve pressure change, is known as "Throttling Range". Throttling range is expressed as the percent of full scale pen movement required to change the controlled valve pressure from 0 to 15 lbs. The position of pin (28), or the Throttling Range, is adjusted by turning throttling range dial (30).

It will be noted that the demand for more steam caused the pen to move downscale, which resulted in a wider opening of the controlled valve. This increased valve opening varies directly with the distance the pen moves below the index. The greater the demand for more steam, the farther the pen must move downscale from the index to obtain this increased steam flow. Since there is a definite controlled valve pressure for each pen position, the increased steam flow can be obtained only as long as the pen remains below the control index; a distance corresponding to the increased steam demand. If the pen is to be returned to the desired temperature, it is necessary to increase the controlled

valve pressure and admit more steam than has resulted from this downscale pen movement. This requires that the flapper moves nearer the nozzle. This can be done mechanically by setting the control index upscale, which, through the linkage, rotates flapper actuating arm counter-clockwise. Of course, the control index is then no longer at the controlled temperature. A similar movement of the flapper toward the nozzle without resetting the index is accomplished manually in the Brown Full Throttlor Unit.

e. Manual Reset

Reset arm (39) has variable width. Turning manual reset screw (23), clockwise, raises arm (39). As the width of arm (39) decreases, spring (29) pulls arm (24) and pin (36) to the right. This moves flapper (5) towards nozzle (4), increasing the controlled valve pressure. Manual adjustment of reset screw (23) may be continued until enough additional steam has been admitted to restore the temperature to the control index.

By similar upscale pen movement, lower valve pressures may be established to reduce the steam flow, and additional reduction of steam flow may be made by turning reset screw (23) to the left.

F. THE BROWN POTENTIOMETER WITH BECK SINGLE AND TRIPLE FUNCTION CONTROL

A description of the Potentiometer Controllers and the Beck Mechanisms is as follows:

1. Description of the Potentiometer Controller

In the single point indicating or recording potentiometer controller, the resistance element is mounted on the back of the instrument frame and has a movable contact which indirectly follows the movement of the pen carriage. This action is described more fully under Proportioning Control.

The multiple point recording potentiometer with control on one point only, contains an oil-immersed selector switch which connects the thermocouples in the proper sequence for recording.

This switch has one or two more segments than the total number of points to be recorded and the control thermocouple is connected to the last two or three segments. A cam, which is mounted on the bevel gear driving the selector switch, operates a mercury control selector switch which is in series with the power supply to the proportioning relay.

The cam is designed so that the mercury switch circuit is opened when the recording thermocouples and the first segment of the control thermocouple are connected to the measuring circuit. This prevents incorrect operation of the control valve while the different temperatures are being recorded.

The mercury switch circuit is closed only when the oil switch is making contact on the second and succeeding segments of the control thermocouple. This allows the control circuit to function only when the controller has come to balance on the control thermocouple.

The resistor for the C-3 timed reset is mounted at the back of the instrument frame between the control resistor assembly and the terminal assembly.

The two-point recording potentiometer with control on both records at the same or different temperature, contains an oil-immersed switch having four segments, the first thermocouple connected to the first two segments and the second thermocouple connected to the last two segments.

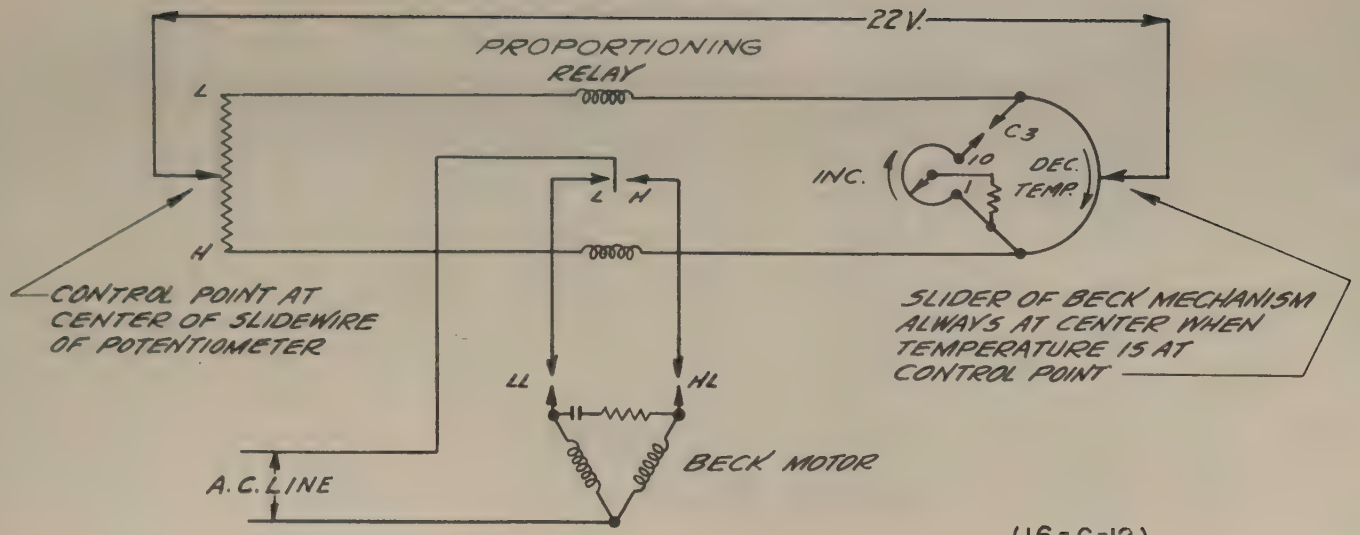
The switch action is the same as for the multiple point recording potentiometer, described above. Two resistors for the C-3 timed reset, one for each Beck Mechanism, are mounted in a separate housing.

The reset contact assembly, which is mounted on the right-hand side plate of single point controllers closes its contact for 2.5 seconds out of each 60 second cycle. With all multiple point recording controllers, a stop-cycle type cam timer is supplied. This timer replaces the C-3 reset contact of the single point controller and is required in order that the C-3 reset action may take place at the proper point in the operating cycle of the instrument. The cycle of operation of the timer is initiated by the contact of the mercury control selector switch at the same time that the proportioning control system is energized.

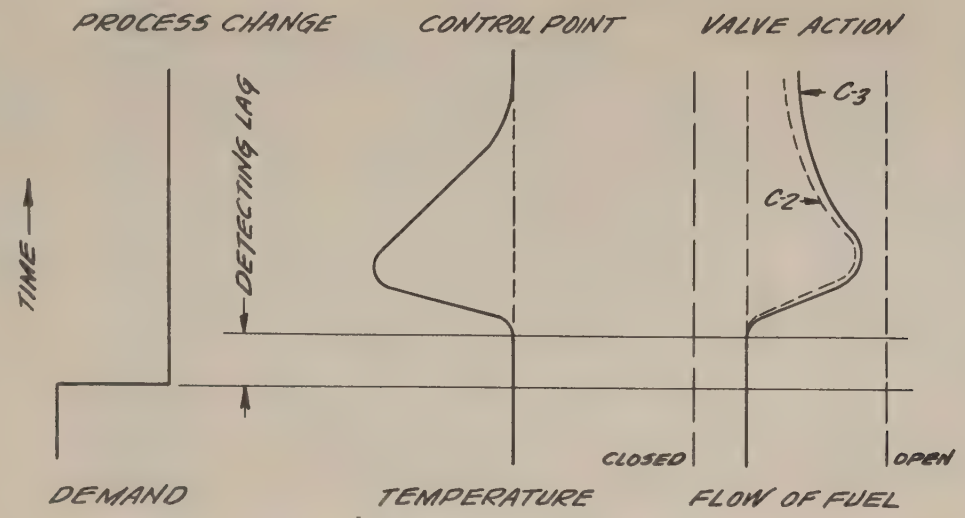
On multiple record controllers, the Reset timer has no effect on the control circuit except when the control selector switch is closed, i.e., on the second and succeeding segments of the control record.

2. Definition of Control Actions

The various control actions are illustrated by the curves of Drawing 16-G-12. The control correction consists of three separate functions, as indicated by these curves.



(16-G-12)



CONTROL CIRCUIT OF THE POTENTIOMETER AND BECK MECHANISM

(16-G-12)

C-1. Primary Control Action is proportional to the magnitude of the temperature deviation and is recovered as the temperature returns to the control point.

C-2. Proportionate Reset is a proportionate part of the C-1 action and is permanent with respect to a given temperature deviation.

C-3. Timed Reset is proportional to the duration of the temperature deviation and is in a direction to force the temperature toward the control point.

The solid line on the fuel rate diagram on Drawing 16-G-12 includes all three control actions and indicates the action of the control valve for a complete cycle of control.

3. Description of Beck Single Control

The electrical control circuit is shown in simplified schematic form on Drawing 16-G-12.

The control slidewire in the potentiometer is connected to the proportioning relay and the slidewire in the Beck Mechanism, forming a bridge circuit as shown, with a 22 volt a-c source of supply introduced at the sliders in the potentiometer and Beck Mechanism. When temperature is at the control point, the slider in the potentiometer is at the center of the slidewire, and for this condition, the slider in the Beck Mechanism is always in the center of the slidewire. The bridge is in balance and the proportioning relay contacts are open. The parts in the circuit are illustrated in this position.

If the temperature changes, the slider in the potentiometer moves along the control slidewire, unbalancing the bridge and causing the relay to contact high or low, energizing the Beck motor to close or open the valve, and, at the same time, to move the slider in the Beck Mechanism along a slidewire in a direction to rebalance the bridge. When the bridge is rebalanced, the relay contacts go to neutral and the Beck motor stops.

This describes the C-1 actions, producing valve motion in an amount proportional to the temperature change and in a direction to oppose the temperature change. As temperature returns to the control point in response to the change in fuel rate, the bridge circuit will become unbalanced in the opposite direction due to the slider in the potentiometer returning along the control slidewire. This will cause the relay to contact and energize the Beck motor in the opposite direction, returning the slider in the Beck Mechanism along its slidewire back toward the center, and, at the same time, returning the valve and consequently the fuel rate back toward, but not all the way, to the value that existed previously.

4. Description of Beck Triple Function Control

a. Proportionate Reset

It is during the period in which the slider in the Beck Mechanism is returning to the center of the slidewire that the C-2 proportionate reset action takes place. The mechanical construction of the Beck Mechanism is such that the slider will return along the slidewire toward the control point faster than it departed, in relation to the speed of the valve. Thus the slidewire in the Beck Mechanism will return all the way to the control point while the valve has returned only part way back toward its original position, thus leaving part of the change in fuel rate permanent with respect to the change in temperature that caused it.

Details of the mechanical parts that cause this change in the relation of the slider in the Beck Mechanism to the position of the valve that the mechanism is operating are shown on Drawing LC-172. A full understanding of these details is probably not possible from this drawing alone, but when viewing an actual mechanism, this explanation together with the drawing, will be more clear. Referring to Drawing LC-172, the slider is carried by the yoke (87) which also carries two pawls (85) and (36). One pawl will be raised by cam (28) when temperature departs in one direction from the control point, and the other pawl will be down in engagement with the ratchet (25). When temperature departs the other way from the control point, the opposite pawl will roll up on the other end of the cam (28) and the first pawl will be down in engagement with the same ratchet (25).

The ratchet and the gear with which the ratchet is integral are driven by pinion (35) directly from the variable speed drive shown at the pinion end of the motor (75). The speed of the gear and ratchet is always faster than that of shaft (71), which turns at a fixed speed with relation to the valve operating crank (60). Shaft (71) moves the slider at the same speed that shaft (71) is turned when temperature departs in either direction from the control point, but when temperature returns toward the control point, the pawl that is

engaged with the ratchet at the time is driven by the ratchet at a speed faster than that of shaft (71) and is forced to move faster than it normally moves by friction drive from detail (39), which is fixed to shaft (71) and against which the yoke which carries the slider is pressed by spring (66).

The percent of reset established for the C-2 action is fixed to agree with the constants of the process being controlled, this setting being made manually by turning the knurled knob (95) as may be required to produce stable control to a definite temperature. Thereafter, reset action is automatic, controlling any load within the capacity of the furnace to the set control point.

b. Time Reset

The C-3 action, which is the timed reset, is produced by the combination of the electrical shunt which is periodically closed across the slidewire in the Beck Mechanism by the contact C-3 shown on Drawing 16-G-12 and the mechanical means just described for producing C-2 action. The C-3 contact closes periodically for a fixed period of 2.5 seconds, and then remains open during the balance of the cycle, which is 60 seconds total time.

This C-3 shunting action has no effect when the bridge is in balance with temperature at the control point because the bridge remains in balance whether this shunt is closed or open. This, of course, is the desired action, as no automatic reset is wanted when temperature is at the control point.

However, if the bridge is in balance with temperature at some place other than the control point, and still within the throttling range, closing of contact C-3 will unbalance the bridge again causing the Beck Mechanism to move its slider and the valve slightly in a direction that would urge the temperature back to the control point.

The amount of this motion depends upon the setting of the rheostat in the C-3 circuit marked 1-10. If this rheostat is at its extreme position in the direction marked increase, it will cause a maximum change in the resistance in the two arms of the bridge formed by the slidewire in the Beck Mechanism, and the step required to rebalance the bridge will be a maximum for a temperature deviation of a given magnitude.

The size of the C-3 step that the mechanism takes is not dependent upon the duration of closing the C-3 contact. This is an important point as it simplifies the mechanical construction of this contact, and makes the C-3 action consistent regardless of any wear on the operating cam that causes the C-3 contact to close.

When the C-3 contact is open, the Beck Mechanism moves the slider back to the position it occupied before it closed, but accompanying this C-3 step, there will have been a change in the relation of the slider to the valve in the Beck Mechanism, in a direction to urge the temperature toward the control point. A 30 ohm fixed resistor is connected into the C-3 circuit so that no adjustment of the rheostat can shunt the valve slidewire to zero.

A study of the shunting circuit described above will show that the size of the C-3 step automatically increases as the temperature departs farther from the control point, reaching a maximum when the slider in the potentiometer reaches the end of the slidewire. Thus the C-3 action changes the flow of fuel in proportion to the magnitude and duration of a temperature deviation, but the C-2 action changes the fuel an amount which is proportional only to the magnitude of the temperature deviation.

This results in stable control without sacrificing the ability in the system to quickly handle sudden changes. Control is stable because of the slowness of the timed reset C-3, and yet fast because of the character of the C-2 reset which always introduces reset as fast as the process can react, but no faster.

Another important characteristic of this system is the fact that all automatic reset stops when temperature deviates beyond the control slidewire in either direction. This renders the system capable of handling batch type heating operations successfully.

G. THE A.T.C. MECHANISMS

1. The A.T.C. Relatrol Controller

a. Description

In this type of controller all mercury switches are omitted and a 100 ohm resistance element required for the A.T.C. Relatrol Controller is substituted in the same compartment at the back of the chassis under the standard cell.

A sliding contactor, which takes its position from the relation of the pen with respect to the control temperature divides the resistor into two arms. As this contactor is moved over the resistance it varies the ratio of the two arms of the electrical transmission system, essentially a Wheatstone bridge. Hence there is no waiting for the making of a high, low, neutral, or some other definite control circuit before a reaction occurs at the motor driven device.

b. Operation

The temperature setting of the control point is readily adjustable by turning the small knurled knob above the door handle. Adjust the setting so the upper black index corresponds to the temperature at which control is desired. Then if the temperature changes from the control setting, the contact of the resistance element will vary its position in response to the temperature change corresponding to the pen movement on the chart.

The change in resistance will be picked up by the receiver in the motor valve and the amount of resultant correction of valve movement will be in proportion to the deviation from the control setting. A large deviation will result in a correspondingly large movement of the valve from the normal opening required to maintain the required temperature. Regulate the motor so that it has the greatest responsiveness to changes of the contact on the resistance element, and adjust the valve setting so the fuel supply is approximately that which is required to maintain the temperature at this point for normal loading and fuel conditions.

As the furnace temperature approaches the control point, the valve will gradually close, reducing the fuel input to the furnace in proportion to the difference between the temperature and the control point. This closing will continue as the control point is approached. If the temperature rises above the control point, further closing results. In other words, the control characteristic secured is that for every position of the temperature away from the control point, within the limits of the sloping control step, there is a corresponding valve position.

After opening the instrument case and swinging the frame forward, it will be seen that the stud of the connecting link is in the extreme outer hole of the lever arm operating the shaft on which the movable contact is mounted. **DO NOT CHANGE THE LOCATION OF THIS STUD.**

2. A.T.C. Balancer Controller

The operation of the A.T.C. Balancer control is similar to the A.T.C. Relatrol control and has in addition the load compensating mechanism.

It is a rotating and adjustable cam which governs the rapidity with which the corrective displacement in valve position occurs. Its function is to force the temperature to return to the control point as rapidly as possible without overshooting after any deviation.

H. THE AUXILIARY SWITCH MECHANISM

The auxiliary switch mechanism is a device for actuating a contact operation at a predetermined point on the scale in response to the position of either the pen carriage or the control carriage.

1. Description

The auxiliary switch mechanism may be mounted on either the right-hand sideplate or the left-hand sideplate of the instrument chassis.

The mechanism may have either one or two single throw switches. Therefore, the contact operation may be either SPST, SPDT, or DPST.

The switch mechanism may be driven from either the control shaft or the pen shaft. Therefore, the switch, may be operated by either the pen carriage or the control carriage as the carriage passes a certain point on the scale.

A maximum of two auxiliary switch mechanisms may be installed on the potentiometer – one on the right-hand sideplate and one on the left-hand sideplate. Each mechanism may be operated either from the control carriage or the pen carriage. Each mechanism may be SPST, SPDT, or DPST.

The switch is tilted when two slotted discs, driven by gears from the pen or control shaft, come in alignment.

2. Application

There are three general functions performed by the auxiliary switch.

First, a contact may be made above the setting of the auxiliary switch in such a manner that an alarm is rung when the temperature indicated by the pen or pointer is too high. Second the contact may be made below the setting when the temperature is too low.

Third the contact may be made when the temperature exceeds a certain limit. Thus, the control system may be shut down as a safety precaution.

I. THE INTERRUPTER SWITCH

The interrupter switch is supplied in a Brown Potentiometer Controller when a circuit is to be broken intermittently. The interrupter assembly is mounted on the right-hand sideplate.

The switch of the interrupter is rated 25 amperes at 110 volts and 15 amperes at 220 volts, and is single pole throw.

The Geneva drive for the interrupter operates from the main drive motor of the balancing mechanism. Therefore, throwing the motor toggle switch will start and stop the interrupter as well.

If the interrupter is not connected into the control circuit inside the controller, the external wiring diagram indicates the connections to the interrupter contact.

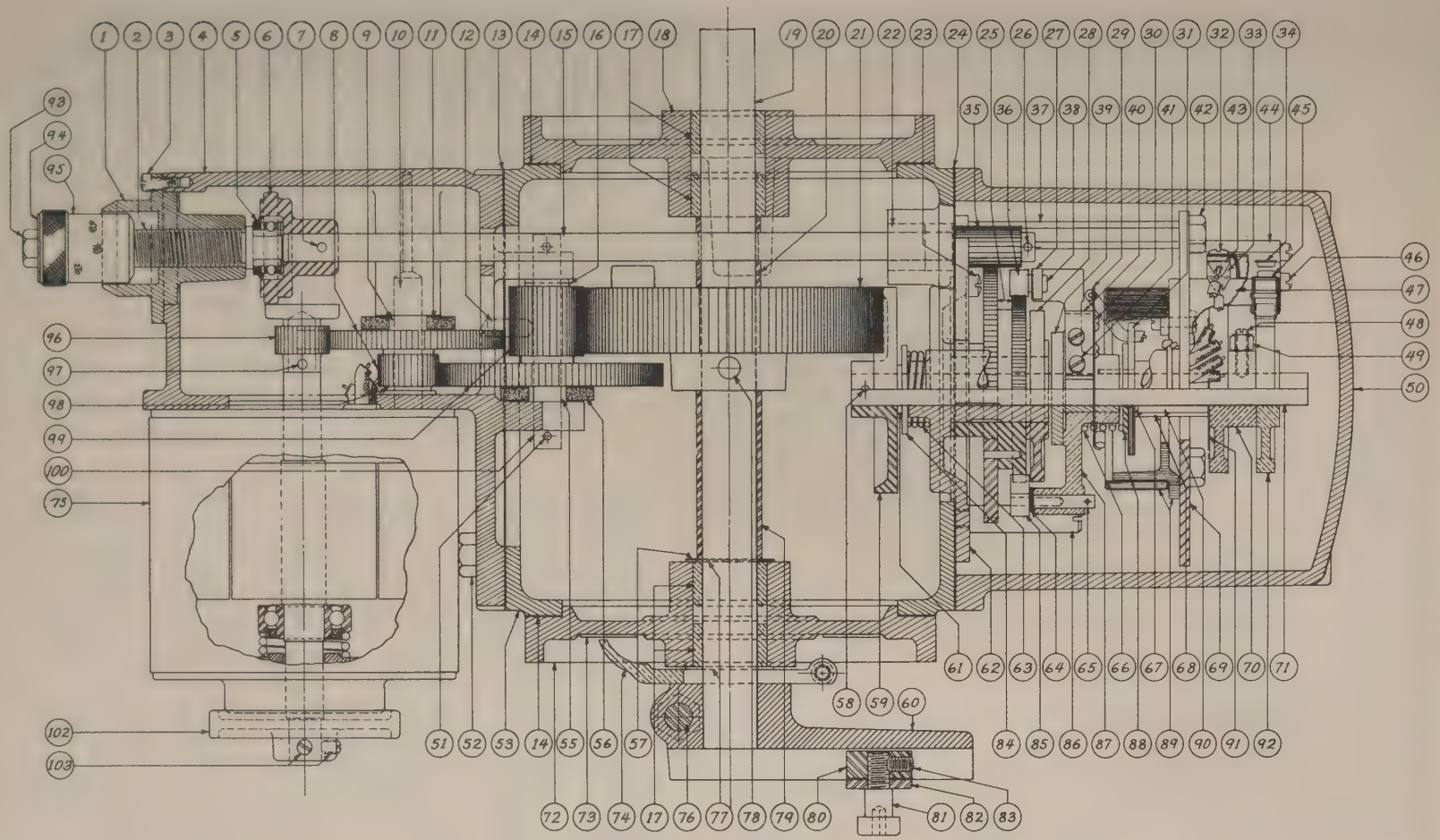
1. Characteristics of Interruption

The length of time that the contact is made may be adjusted from 1 to 7 seconds in steps of 1/2 second.

The time cycle in which the contact is made may be adjusted independently to values of 15, 30, 60, or 120 seconds.

This time includes the "on" time as well as the "off" time.

If a longer time of contact is desired, the switch may be reversed in its clip. Thus, if a 9 second contact out of 15 seconds is desired, the pin should be placed in the hole marked 6 (15-9).



2722 BECK MECHANISM

HAROLD BECK COMPANY
PHILADELPHIA, PENNA.

DRAWN	CHECKED	APPROVED	X NO.	SCALE
		HCB	—	—
		6-6-43	DRAWING NO.	
REF.			LC-172	

SECTION 1358
Issue 2

DESCRIPTION OF AND DATA ON COMPONENT PARTS OF TYPE 113 MECHANICAL POTENTIOMETER

The parts covered in this section and the order in which they occur are listed below:

A. Measuring Circuits
B. Slidewires and Resistance Spools
C. Galvanometer Assembly
D. Thermocouple Switches
E. Current Supply for Measuring Circuit
F. Description of Standard Cell
G. Description of Motor
H. Humidity Compensator
I. Charts and Chart Reroll
J. Pen Carriage
K. Print Hammer Mechanism
L. Print Wheel Mechanism
M. Thermocouple Burn-out Safety Feature
N. Mercury Switches

A. MEASURING CIRCUITS

The null or balance system of measurment is used in both Potentiometer Pyrometers and Resistance Thermometers. With this system the galvanometer pointer only indicates an unbalance between the thermocouple and the slidewire.

A description of the Potentiometer Pyrometer and Resistance Thermometer circuits are as follows:

1. The Measuring Circuit of Potentiometer Pyrometer

Drawing 16-G-17 shows a schematic diagram of measuring circuit number 1. Drawing 16-G-18 is the internal wiring diagram for circuits numbers 2, 3, 4, and 6. The duplex slidewire maintains a constant resistance in the galvanometer circuit so that the galvanometer sensitivity is constant for all parts of the scale. Thus, a given change in the measured emf will produce the same galvanometer deflection at any point on the scale, and the galvanometer damping characteristics remain constant for a given external resistance (thermocouple plus extension leads). With multiple recorders, the external resistance may vary, depending upon the resistance of the different thermocouples and extension leads. In such cases, the damping of the galvanometer is adjusted to the average condition. Where the external resistance is unusually high, the No. 5 spool may be shunted out to improve the damping characteristics. This will not affect the accuracy of calibration.

The cold junction compensation spool is located in the terminal plate so that it will be at the same temperature as the extended cold junction of the thermocouple.

The current drawn from the battery with this circuit is 4 milliamperes, which gives a dry cell life of about eight months.

Some ranges use a minor modification of the above circuit and also draw 10 or 20 milliamperes from the battery. Circuits II to VI have slidewires with solid returns.

Details of the various circuits applying to a given instrument may be obtained from the factory by stating the serial number of the instrument.

The following table shows details of the various potentiometer pyrometer circuits. It will be helpful in determining the type of circuit being used and the correct slidewire assemblies, cold junction spools, step tables, and galvanometers required. It will also help in locating trouble in the circuit as resistance values for various portions of the circuits are listed. Several of the resistors are not listed as their value varies, depending on the range and suppression.

NOTES-

1. ON SLIDE WIRES WITH SPANS ABOVE 60 MILLIVOLTS AND SLIDE WIRES WITH SAFETY FEATURE, A CONNECTION IS MADE BETWEEN THE #1 POST AND THE SHORT STUD SUCH THAT RESISTOR R_s (1) SHUNTS THE GALVANOMETER IN ALL SWITCH POSITIONS.
2. RESISTOR R_g (6) IS USED ONLY ON SLIDE WIRES WITH SAFETY FEATURE.

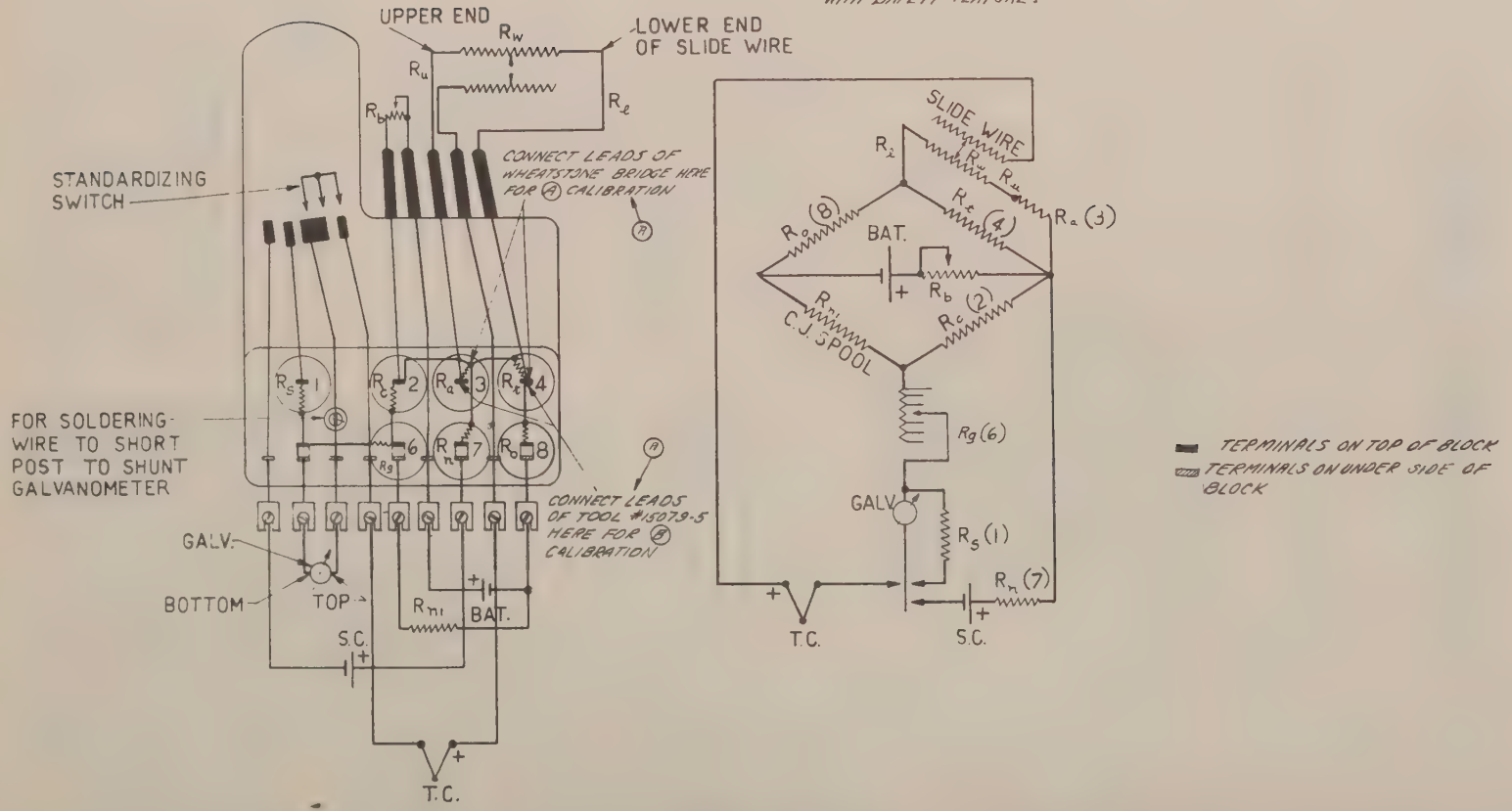
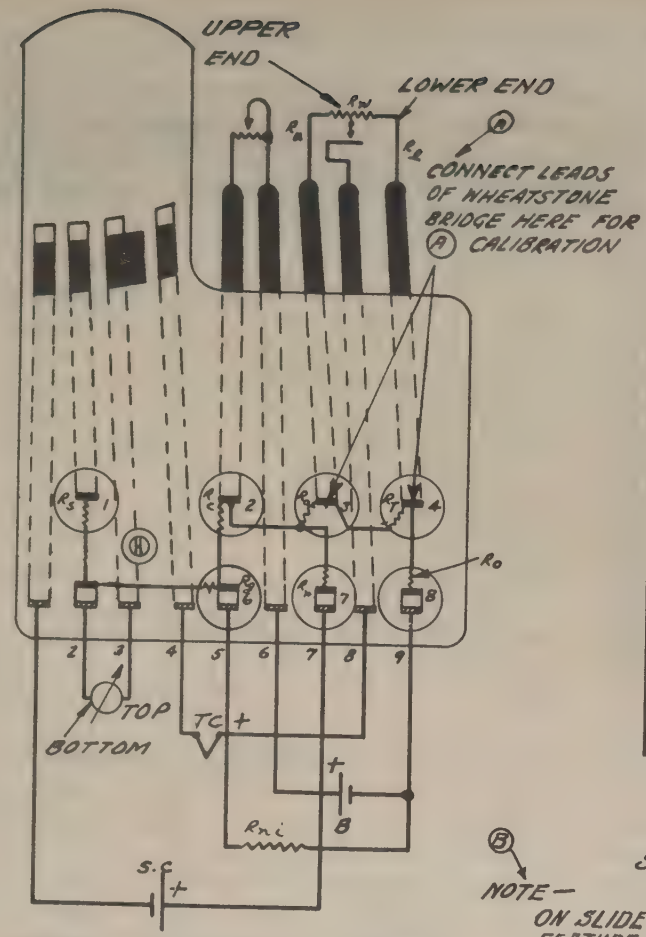


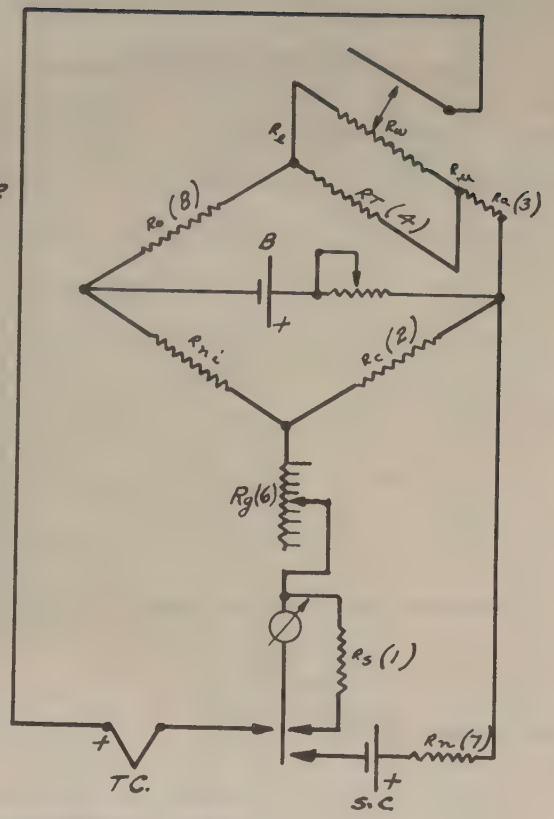
Fig. 16-G-17

SCHEMATIC WIRING DIAGRAM

RECORDING OR SINGLE RANGE INDICATING POTENTIOMETER



ACTUAL INSTRUMENT CIRCUIT



SCHEMATIC CIRCUIT

TERMINALS ON TOP OF BLOCK

TERMINALS ON UNDER SIDE OF BLOCK.

NOTE— ON SLIDE WIRE WITH SAFETY FEATURE, A CONNECTION IS MADE BETWEEN #1 POST AND SHORT STUD SUCH THAT RESISTOR $R_s(1)$ SHUNTS THE GALVANOMETER IN ALL SWITCH POSITIONS.

Drawing 16-G-18
Brown Potentiometer Pyrometer Circuit

TABLE I

CIRCUIT NUMBER	TYPE OF T/C	MILLIVOLT SPAN IN MV	MILLIVOLT SUPPRESSION IN MV	NOMINAL T/C CIRCUIT RES. (Incl. Gal.) (OHMS)	CIRCUIT DIAGRAMS	MAX. ALLOWABLE T/C RES. FOR MV SUPPRESSION (OHMS) 0 MV	5 MV	10 MV	15 MV	20 MV	25 MV	30 MV	35 MV	40 MV	NUMBER OF DRY CELLS	BATTERY CURRENT MA
I	Base Metal - Section I to V	* 20.00 to 65.00 ** 20.00 to 65.00	up to 10.00	96	1-D-1523	18	15	13	–	–	–	–	–	–	1	4
II		* 20.00 to 40.00 ** 20.00 to 40.00	10.00 - 40.00	96	D-2209	46	44	42	40	38	36	34	32	30	1	4
III		* 8.80 to 20.00 ** 10.30 to 20.00	up to 40.00	70	D-2209	30	29	28.5	28	27.5	26.5	26	25.5	25	1	10
IV		* 6.5 to 8.80 ** 8.80 to 10.30	up to 40.00	40	D-2209	6	5	4.5	4	3.5	3	2.5	2	–	1	10
V		* 5.0 to 6.5 ** 6.5 to 8.87	NONE	20	D-2210	2	–	–	–	–	–	–	–	–	2 in. Parallel	20
VI	Rare Metal	* 5.00 to 20.00 ** 6.50 to 20.00	up to 12.00	20	D-2209	3	2.5	2	1.5	–	–	–	–	–	1	10

* Without Burn-out
** With Burn-out

When millivolt span is near either limit the next wider or steeper step table may give better operation.

TABLE II

CIRCUIT NUMBER		SLIDEWIRE ASSEMBLY: MECHANICAL BALANCE	SLIDEWIRE ASSEMBLY: MANUAL BALANCE	SLIDEWIRE ASSEMBLY: DESCRIPTION	COLD JUNCTION RESISTORS: MA	IC	MV	QR	HER	CC	RESISTANCE IN OHMS: R_n	R_c	R_b	R_s	R_g IN STEPS OF APPROX. 6 OHMS	"A" VALUE IN OHM RES.
I	*	15079–Range	74749–Range	Duplex approx. 40 ohms	Section 1 to IV 15266 (MA) 4.705 ohms at 75° F	Section 1 to IV 15267 (IC) 6.025 ohms at 75° F	Section 1 to IV 15247 (MV) 4.705 ohms at 75° F			Section 1 to IV 15266 (MA) 4.705 ohms at 75° F	800	509.5	–	△	NONE	$A = .5(10194 MV_c - MV_{mn} + .0053 MV_s)$
	**	17011–Range									600			70	6.2 to 18.0 4 steps	
II	*	17785–Range	74748–Range	Solid Return approx. 20 ohms							800	509.5	–	70	8.2 to 47.0 in 6 steps	$A = .5062 MV_s$
	**	17787–Range									600					
III	*	17060–Range	74747–Range	Solid Return approx. 20 ohms							1200	509.5	–	55	6.2 to 36.0 in 6 steps	$A = .1266 MV_s$
	**	17653–Range									1200					
IV	*	17060–Range	74747–Range	Solid Return approx. 20 ohms							400	509.5	–	20	1.0 to 6.2 in 6 steps	$A = .1266 MV_s$
	**	17653–Range									600					
V	*	17781–Range	17781–Range	Solid Return approx. 20 ohms	17036-17 1.568 ohms	17038-7 2.018 ohms					400	509.5	50	11	1.0 to 6.2 in 6 steps	$A = .07234 MV_s$
	**	17783–Range									600					
VI	*	17060–Range	74747–Range	Solid Return approx. 20 ohms				15267 (QR) 0.650 ohms	15459 (HER) 0.686 ohms		400	509.5	–	11	1.0 to 6.2 in 6 steps	$A = .1266 MV_s$
	**	17653–Range									600					

* Without Burn-out Feature
** With Burn-out Feature

△ On spans about 60 MV connect R_s permanently across the galvanometer on all instruments without burn-out feature. Refer to wiring diagram for terminals to which the Wheatstone bridge is to be connected for checking the A Res. value.

TABLE III

CIRCUIT NUMBER	STEP TABLES			GALVANOMETERS	
	NUMBER	SPAN IN MV		MECHANICAL BALANCE	MANUAL BALANCE
		WITHOUT BURN-OUT	WITH BURN-OUT		
I	40602 40091	20.0 to 32.0 32.0 to 65.0	20.0 to 39.0 39.0 to 65.0	15398 1 red dot	15665 1 red dot
II	40602 40091	20.0 to 32.0 32.0 to 40.0	20.0 to 40.0 -- --	15398 1 red dot	15665 1 red dot
III	40601 40602	8.8 to 13.1 13.1 to 20.0	10.3 to 15.5 15.5 to 20.0	15398 1 red dot	15665 1 red dot
IV	40601 40602	6.5 to 8.8 -- --	8.8 to 10.0 -- --	17070 1 green dot	15665 1 red dot
V	40601	5.0 to 6.5	6.5 to 8.87	17069 1 blue dot	17260 1 green dot
VI	40601 40602 40091	5.0 to 8.0 8.0 to 14.0 14.0 to 20.0	6.5 to 8.7 8.7 to 15.5 15.5 to 20.0	17069 1 blue dot	17260 1 green dot

NOTE: When millivolt span is near either limit the next wider or steeper step table may give better operation.

2. The Measuring Circuit of the Balanced Wheatstone Bridge Resistance Thermometer

Drawing 16-G-19 shows a schematic diagram of the measuring circuit, which consists of a slidewire, galvanometer, bulb, battery, and resistors connected in the form of a Wheatstone bridge.

The bulb is a coil of nickel wire mounted in a suitable protecting tube with terminal head. The resistance of the nickel wire varies with the temperature surrounding it, in accordance with definite physical laws and can be used as a measure of temperature.

The circuit is so designed that when the resistance of the bulb is equivalent to the minimum temperature of the range, the bridge is balanced (galvanometer deflection is zero) when the slider is at the lower end of the slidewire. Conversely, when the resistance of the bulb is equivalent to the maximum temperature of the range, the bridge is balanced when the slider is at the upper end of the slidewire.

When a temperature change at the bulb causes a corresponding resistance change, the bridge becomes unbalanced and the galvanometer pointer deflects. The instrument mechanism functions to move the slide so as to restore the electrical balance. When the galvanometer deflection becomes zero, indicating electrical balance, the mechanism ceases to function, and the position of the slider on the slidewire is an indication of the temperature of the bulb.

A pointer or pen connected with the slider and moving with it, travels over the scale or chart, graduated in terms of temperature.

Since the circuit is normally balanced, the position of the slider, and therefore, the accuracy of the instrument is independent of the battery current and voltage, hence the lack of necessity for standardizing the battery current as in a potentiometer.

The slidewire used with Resistance Thermometers and data regarding resistance valves, number of cells, step tables, and scales are listed in table number 4.

B. SLIDEWIRES AND RESISTANCE SPOOLS

The slidewire is the variable resistance in the potentiometer circuit. The assembly is built upon a bakelite molding and carries the entire electrical circuit of the potentiometer with the exception of the nickel cold junction compensating coil and the interconnecting cables.

The slidewire, Figure 1358-1, is over 40" long and is laid in a groove parallel to either a return solid conductor or a wound resistance wire similar to the slidewire resistor which is connected to the thermocouple and galvanometer. The return conductor eliminates the necessity of using a flexible connection.

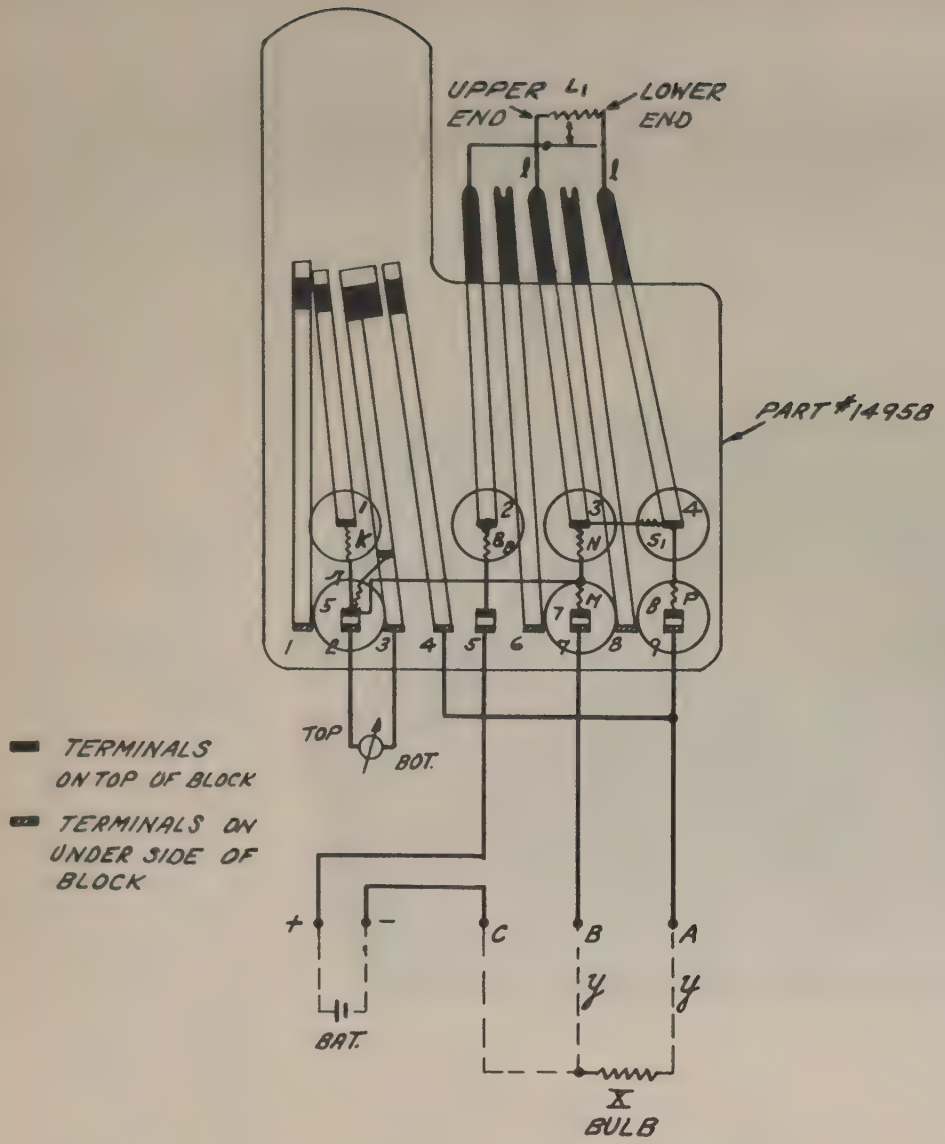
The 40" slidewire has 1600 convolutions which means that 1600 possible balancing points are provided over the range of the instrument. This is practically the equivalent of a continuous wire. Each convolution represents about .06% of full scale range. The slidewire is made of bare manganin wire space wound on a No. 10 gauge copper Formex insulated core. With a long slidewire, the wire can be of larger diameter, and any wear which occurs in time will have less effect on the accuracy. Calculations will readily show that a larger resistance wire, wound on a proportionally larger core (as is evidently proper in consideration of the distortion produced in wire wound into small helices) will give more convolutions and a longer finished slidewire, with less resistance, than can be obtained by using small wire wound on a small short core. The larger diameter resistance wire wound on a larger core has the further advantage that wear produced by the sliding contactor has very much less effect upon the slidewire resistance; 1st, because more metal has to be removed for a certain depth to be reached thus the progress is slower; 2nd, because wear to a given depth affects the cross-sectional area of the wire less; and 3rd, because the larger core wire confines the worn section to a smaller fraction of the total length of the resistance wire. The large diameter wire also enables the contacts to be broad, with a good bearing surface.

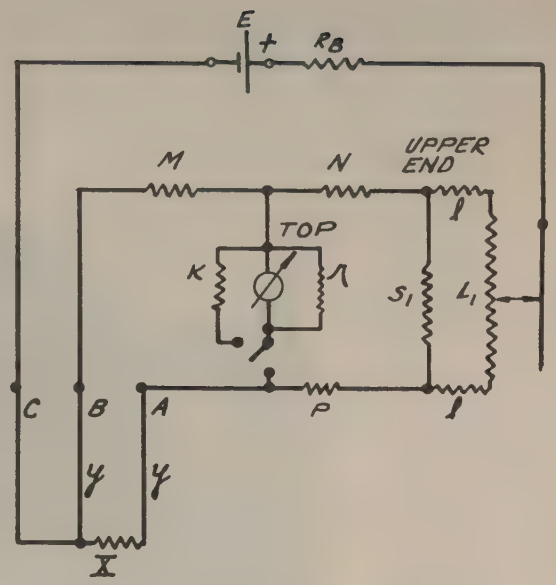
The contactor consists of a short cylinder made of a special silver alloy somewhat softer than the resistance wire used in the slidewire so that if any wear does occur, it will be on the contactor which is readily replaced. The contactor material has been chosen because of its physical and electrical properties. 5-1/32 revolutions of the slidewire shaft move the contactor from one end to the other of the slidewire.

The slidewire is enclosed in a glass container and is usually immersed in oil. It is designed for oil immersed operation. No corrosive gases, fumes, etc., usually present in manufacturing plants, can come in contact with the slidewire. The slidewire and contacts are constantly washed clean and lubricated in the special oil which cuts down the wear on both the slidewire and the contactor.

TABLE IV

RECORDER CHART NO.	RANGE	BULB	RECORDER AND AUTO. BAL. INDICATOR SCALE NUMBER	MAN. BAL. INDICATOR SCALE NO.	SLIDEWIRE 15482-	GALVANOMETER		STEP TABLE (REC. ONLY)	NO. OF DRY CELLS	K 15414	R_B 15412	N 15843	A	r 15415	M 15847	P 15848	CURRENT DRAIN (AMPS.)	LEAD RES (OHMS)	TAP SETTING ON 73787 RECTIFIER
						RECORDER	INDICATOR												
5900	-40 to +140°F	A	77078-5900	65900	5900	15398	15665	40601	2	410	97	347.01	40	48	466.00	346.24	0.0054	2.5	3
5901	0 to 100°F	A	77078-5901	65901	5901	15398	15665	40601	2	376	186	294.68	40	48	530.00	294.06	0.0046	2.5	3
5902	-60 to +120°F	A	77078-5902	65902	5902	15398	15665	40602	2	328	294	150.60	40	52	500.00	149.81	0.0044	2.5	3
5903	0 to 150°F	A	77078-5903	65903	5903	15398	15665	40602	2	312	102	196.93	40	50	565.00	195.19	0.0057	2.5	3
5904	0 to 220°F	A	77078-5904	65904	5904	15398	15665	40091	2	345	97	133.99	40	52	610.00	132.68	0.0058	2.5	3
5905	100 to 320°F	A	77078-5905	65905	5905	15398	15665	40601	2	414	140	277.54	40	48	689.00	276.33	0.0044	2.5	3
5906	0 to 250°F	A	77078-5906	65906	5906	15398	15665	40602	2	226	394	118.23	40	53	635.00	115.89	0.0036	2.5	2
5907	0 to 300°F	A	77078-5907	65907	5907	15398	15665	40091	2	200	122	98.56	40	55	675.00	95.42	0.0054	2.5	3
5908	90 to 110°F	A	77078-5908	65908	5908	15455	15673	40600	2	600	16	498.09	12	20 10	600.00	498.24	0.0049	2.5	3
5909	60 to 80°F	A	77078-5909	65909	5909	15455	15673	40600	2	520	67	481.58	12	2480	559.00	481.14	0.0047	2.5	3
5910	40 to 120°F	A	77078-5910	65910	5910	15455	15673	40091	2	477	23	390.22	40	none	572.00	389.45	0.0054	2.5	3
5911	-20 to +110°F	A	77078-5911	65911	5911	15398	15665	40601	2	329	399	221.22	40	49	525.00	219.27	0.0036	2.5	2
5912	-60 to +60°F	A	77078-5912	65912	5912	15398	15665	40601	2	322	326	227.03	40	50	470.00	223.59	0.0041	2.5	2
5913	85 to 145°F	A	77078-5913	65913	5913	15398	15665	40600	2	267	97	164.38	12	51	622.00	164.16	0.0056	2.5	3
5914	225 to 375°F	A	77078-5914	65914	5914	15398	15665	40601	2	249	191	133.69	22	52	925.00	133.23	0.0039	2.5	2
5915																			
5916																			
5917	10 to 40°F	A	77078-5917	65917	5917	15455	15673	40601	2	505	166	493.08	20	2900	498.00	493.18	0.0045	2.5	3
5918	-25 to +5°F	A	77078-5918	65918	5918	15455	15673	40601	2	472	193	473.21	20	none	454.00	472.54	0.0042	2.5	3
5919	-14.22 to +96.89°F	A	77078-5919	65919	5919	15398	15665	40602	2	226	394	118.23	40	53	635.00	115.89	0.0036	2.5	2
5920	15 to 75°C	A	77078-5920	65920	5920	15398	15665	40601	2	140	251	74.01	10	62	622.00	73.36	0.0046	2.5	3
5921	-20 to 120°F	A	77078-5921	65921	5921	15398	15665	40602	2	318	128	206.24	40	50	535.00	202.82	0.0055	2.5	3
5922	+50 to 110°C	A	77078-5922	65922	5922	15398	15665	40601	2	460	46	316.06	40	47	716.00	313.95	0.0049	2.5	3
5923	-80 to +140°F	A	77078-5923	65923	5923	15398	15665	40602	2	221	417	122.54	40	53.5	515.13	117.06	0.0036	2.5	2
5924	100 to 150°C	A	77078-5924	65924	5924	15398	15665	40091	2	191	988	102.04	10	55.5	850.00	101.58	0.0019	2.5	2
5925	+40 to -30°C	A	Refer to Engineering Department																
5926	+30 to 100°F	A	77078-5926	65926	5926	15455	15673	40602	2	505	270	440.37	40	2900	553.00	438.30	0.0036	2.5	4
5927	+60 to 90°F	A	77078-5927	65927	5927	15455	15673	40601	2	564	22	535.80	20	1810	566.00	535.04	0.0048	2.5	4
5928	0 to 25°F	A	77078-5928	65928	5928	15455	15673	40602	2	560	74	548.74	40	1850	546.00	546.98	0.0053	2.5	3
5929	0 to 100°C	A	77078-5929	65929	5929	15398	15665	40602	2	292	45	172.34	40	50	639.00	168.39	0.0057	2.5	2
5930	-100 to +200°F	A	77078-5930	65930	5930	15398	15665	40602	2	177	677	88.86	40	57	551.00	81.67	.0028	2.5	2
5950	-40 to +60°C	A	77078-5950	65950	5950	15398	15665	40602	2	233	250	155.52	40	51	530.00	153.64	0.0046	2.5	3
5951	-40 to +100°C	A	77078-5951	65951	5951	15398	15665	40091	2	214	112	111.59	40	54	580.00	108.78	0.0060	2.5	3
5952	0 to 150°C	A	77078-5952	65952	5952	15398	15665	40602	2	193	393	113.67	40	53	700.00	111.15	0.0035	2.5	2
5953	-25 to +225°C	D	77078-5953	65953	5953	15455	15673	40601	2	600	191	767.08	40	1600		765.68	0.0034	2.5	2
5954	0 to 150°C	Spec.	77078-5954	65954	5954	15398	15665	40602	2	159	423	169.43	40	59	140.00	164.92	0.0048	2.5	





SCHEMATIC CIRCUIT

REFER TO DWG. D-2192 (B)
FOR MULTIPLE RECORD CIRCUIT.

(A)

Drawing 16-G-19
Schematic Wiring Diagrams of
Balanced Wheatstone Bridge Resistance Thermometer Single Record

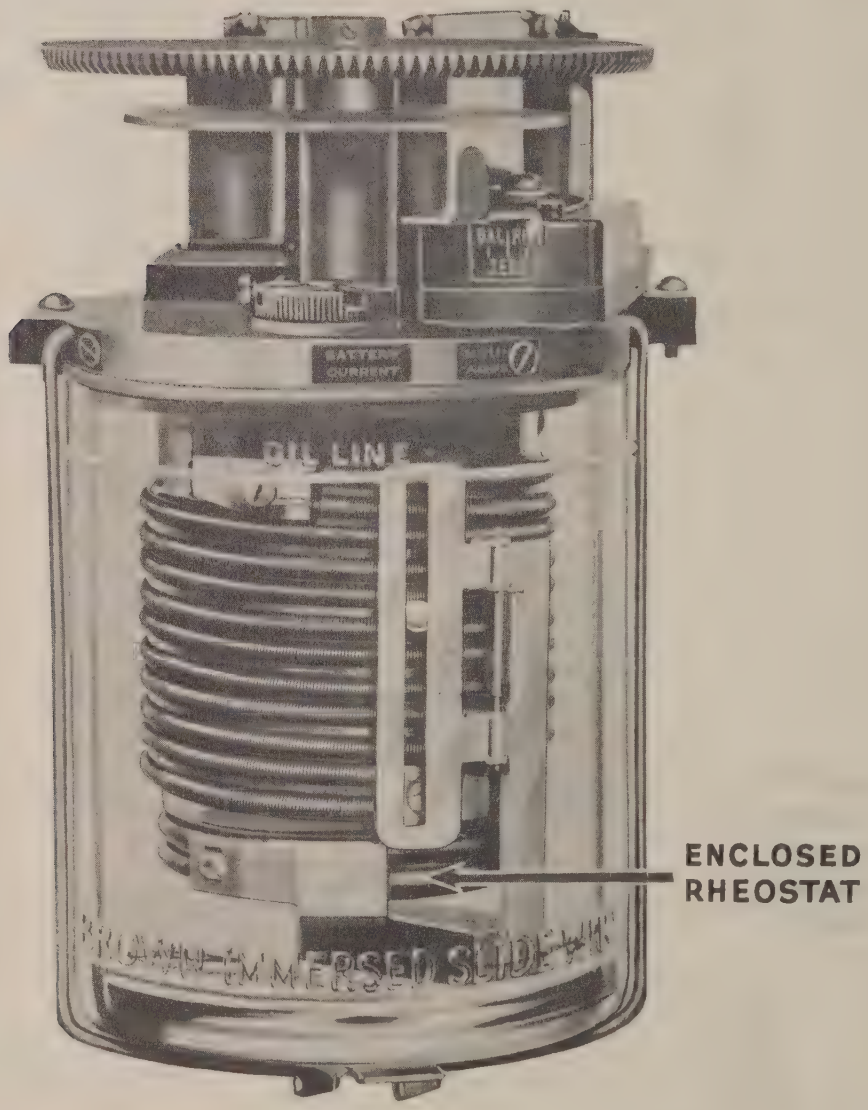


Figure 1358-1
Slidewire Unit

A rheostat for balancing the battery against the standard cell is shown in Fig. 1358-1 below the main slidewire. This is operated from the solid gear shown below the large aluminum bevel gear at the top of the figure. The handle for operating a switch for use in the standardizing and mechanical balancing operations is shown immediately below the right-hand side of the solid gear. The switch contacts are placed inside a bakelite housing as shown. This switch is of the three-leaf type, sliding diagonally across switch contacts that protrude from the bakelite molding which forms the base. All the conductors, including the switch connections, are composed of metal strips and rods moulded into the bakelite form. Some of these extend upward to form both leads and supports for the spools.

C. GALVANOMETER ASSEMBLY

The galvanometer is of the suspension type and is entirely enclosed in its own housing inside the instrument case. Figure 1358-2 is a photo of the galvanometer assembly removed from the housing. Its movement can be observed through a removable window in the front of its cover. This covering can be instantly removed without removing a single screw and without tools. It consists of a metal back plate, bakelite cover, and window. Spring clips on the metal back plate and on the frame around the window hold the cover in place. The cover protects the galvanometer from mechanical injury and from dirt, dust, and fumes and prevents air currents from upsetting the operation of the instrument when the case is opened for changing charts, making notes on the record, etc., or when the hinged frame is swung out for inspection.

This galvanometer is designed to a uniformly high responsiveness under all practical operating conditions. The balancing mechanism exerts no strain upon the galvanometer pointer because the pointer and suspensions are relieved of practically all work by the introduction of a "secondary pointer" system, wherein a rugged secondary pointer assumes a position in magnified proportion to the galvanometer pointer position and then governs the adjustment of the pen and the slidewire contact. The mechanical movements of the secondary pointer are comparatively large. As a result, no adjustments are needed to take up wear on either the pointer or the contacting mechanism and the highest accuracy is maintained over long periods of continuous operation.

Three types of coils, similar in appearance but having different windings and consequently different characteristics, are furnished for the three different measuring circuits used, requiring battery currents of 4, 10, and 20 milliamperes.

The pointer is comparatively long and is so designed in order to amplify the coil movement so that comparatively wide steps on the step table can be used for small movements of the coil.

The step table mechanism which contacts with the pointer is placed inside the galvanometer housing and is operated by a horizontal shaft entering through the right side. This mechanism is moved upward by a light spring when permitted by the right-angle end of the horizontal shaft called the table lever shaft. The effort required to oscillate this mechanism is so slight that the step table is brought against the galvanometer pointer with a force of only a few grams, thus greatly prolonging the life of the pointer tip. The step table rises until one or the other of its steps comes to rest against the galvanometer pointer. In its upward motion, the step table has a series of possible stopping places, one or the other of which is selected according to the deflection of the galvanometer pointer. This step table, then, positions the table lever shaft, which positions the table lever, which is on the inside of the right-hand sideplate and extends through the sideplate to position the secondary pointer.

The steps on the step table are steeper in the middle than at the ends, with the result that very slight deflections of the galvanometer pointer away from the middle or neutral step will produce substantially large and definite differences in the secondary pointer position. As the step table steps become wider at greater distances from the neutral step, the magnification of the secondary pointer motion diminishes, making it possible for the largest steps of the pen to be eighty times larger than the smallest one. For narrow ranges, a step table is used which has steps of the same height as those used for wider ranges, but having narrower faces, making steeper steps. With such a steep step table, the instrument will operate with the same large steps although the galvanometer deflection is less.

The galvanometer pointer projects through two rectangular openings, one of which is fixed and the other movable. The upper edge of the rectangular opening in the fixed piece is known as the upper clamping bar. The lower edge of the rectangular opening in the movable piece is known as the lower clamping bar. The upper edge of the rectangular opening of the movable piece is known as the stripper bar.

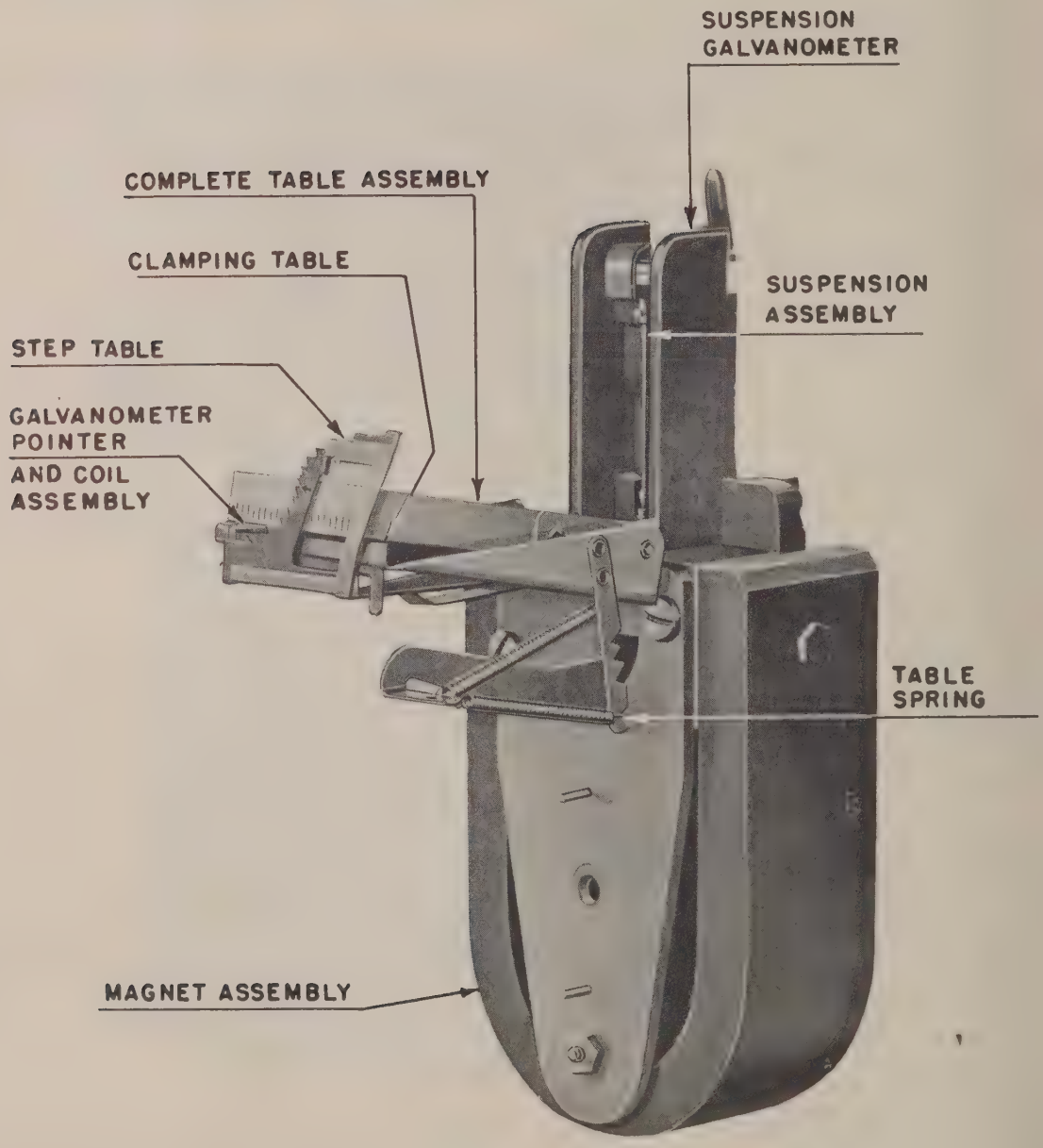


Figure 1358-2
Galvanometer Assembly

An ear on the upper right-hand corner of the step table contacts a projection on the movable piece during the downward motion of the step table and pulls the movable piece down until in its final position the stripper bar is 0.025" below the upper clamping bar. This is done so that the galvanometer pointer cannot stick to the upper clamping bar. This distance of 0.025" is obtained by adjustment of the ear of the step table. In its upward movement, the step table first allows the lower clamping bar to clamp the pointer lightly but positively between the lower clamping bar and the upper clamping bar, and then the step table itself comes up to take its position from the position of the galvanometer pointer. There is no possibility that the pointer can move away from its proper position.

1 Data

There are four types of galvanometers for use with the various ranges. The following table lists the part numbers, resistance of the coil, and color coding for identification.

GALVANOMETER PART NUMBER		COLOR CODING	NOMINAL RESISTANCE OF COIL PLUS SUSPENSION IN OHMS
MECHANICAL BALANCE	MANUAL BALANCE		
15398	15665	RED	28
15455		YELLOW	200
17069		BLUE	8
17070	17260	GREEN	21

D. THERMOCOUPLE SWITCHES

1. Description

The thermocouple switches have brass contacts and phosphor bronze brush fingers. The switch base is designed so the contacts can be covered to a depth of 1/16" with the Brown Instrument immersion oil. The switches are driven and indexed properly by a Geneva gear.

Two types of switch assemblies are used, the difference being, in the mounting bracket, in the ratio of the drive gears and the addition of the record indicating dial used on the print hammer instrument. These two types of switches are not interchangeable, due to the difference in the ratio of the switch driving gears.

E. CURRENT SUPPLY FOR MEASURING CIRCUIT

Two types of current supply are available for use with the Brown Potentiometer Pyrometer. They are: (1) carbon cells; (2) dry cells.

The number of cells to be used depends upon the current requirements of the circuit.

The battery current required to operate a Potentiometer Pyrometer is stated on the slide-wire nameplate.

The dry cell consists of a hollow zinc cylinder, which is the negative pole, and a carbon rod, which is the positive pole. The electrolyte is a paste of sal ammoniac. The space between the carbon and zinc is filled with a mixture of granulated carbon and manganese-dioxide, the latter being the depolarizer. In new cells the open-circuit emf is between 1.5 and 1.6 volts.

Dry cells should be mounted in a location free from moisture and excessive heat or cold. Large temperature variations at the cell should be avoided for best instrument operation. The center terminal of the cell is positive (+) and the outside terminal is negative (-).

Except in the Manual Balance Indicator, space is provided inside the instrument for one dry cell. Where more than one cell is required, the cells must be located external to the instrument.

A special battery container can be supplied. It should be placed in the thermocouple lead conduit with its removable cover accessible from the left side of the instrument. When a group of instruments is to be mounted close together in a row, the dry cell container should be located above or below the instruments so the covers can be removed from the front. When the instrument is flush mounted on a panel, the dry cell container is located in the thermocouple lead conduit at the back of the instrument.

The proper number of cells to be used for a given instrument is covered in the following table:

CELL REQUIREMENTS FOR BROWN POTENTIOMETERS		
CURRENT REQUIREMENT (MILLIAMPS)	NO. OF DRY CELLS	NO. OF CARBON CELLS
4	1	1
10	1	1
20	2	2

Where 2 cells are used connect them in series.

F. DESCRIPTION OF STANDARD CELL

In the actual process of measurement, the unit or standard which is used for comparison must be a definite, unchangeable thing. The need of a standard emf was recognized in the early days of the electrical industry. The type of cell most generally used for this purpose at the present time is the Weston or cadmium cell, which possesses to a great degree the necessary characteristics of permanence and reproduceability.

The particular type of cell used in the Brown potentiometer is known as the unsaturated acid type, which has a solution that is saturated at 4°C. and a voltage that does not vary to any appreciable extent with temperature changes within the usual operating range. This cell is usually accompanied by a certificate stating its exact voltage, which at 20°C is between 1.0185 and 1.0195 volts. With the electrolyte slightly acid, the cell has a lower voltage, which depends on the acidity, but shows no perceptible change with age.

The standard cell consists of a glass container shaped like the letter "H" and suitably mounted on a bakelite plate provided with binding posts to which platinum lead wires are attached. Cadmium amalgam is used for the negative pole, pure mercury for the positive pole (the heavier of the two legs) and cadmium sulphate for the electrolyte. The particular advantage in the use of cadmium arises from the low temperature coefficient and small temperature lag thus obtainable. It also has a longer life and polarizes less rapidly. Polarization is the name applied to the changes produced in the relative concentrations of the electrolyte at the two poles of a cell or to the production at the poles of new chemical substances (such as hydrogen) as a result of the flow of current through it. Polarization always tends to reduce the effective emf of the cell.

No appreciable current can be taken from a standard cell without altering its emf, due to polarization. It is found that the change is not permanent, for the cell gradually recovers its original emf; of course, the cell is unreliable until the recovery is complete. Theoretically, the life of a cell is unlimited, but actually, because of the slight drain while balancing, the cell has a useful life span which is normally many years. The key which closes the standard cell circuit should be used only momentarily.

G. DESCRIPTION OF MOTOR

Where alternating current (a-c) service is available, which represents 95% of the instrument service in the United States, a synchronous capacitor type motor without brushes or (certrifugal switch) is used, eliminating possible trouble with brush and commutator contacts, arcing, and speed governors.

The speed of a synchronous motor depends solely upon the frequency of the power plant generator supplying electric energy to it, rather than the voltage. Hence, normal load and voltage variations within 10% of the rated voltage have no effect. The motor is therefore said to run in synchronism with the source of supply and is called a "synchronous" motor.

The motor has a speed of 1800 RPM at 60 cycles or 1500 RPM at 25 cycles, which, through a gear reduction unit, is reduced to 16-2/3 RPM at the output shaft. A constant speed motor is necessary so that the chart keeps accurate time.

D-c motors are also supplied. These are necessarily brush type motors. The speed depends directly upon the line voltage.

Variations in d-c voltages in industrial plants frequently make it difficult to obtain proper chart timing.

The gear reduction unit is built into the motor bonnet and is packed in grease, as are also the ball bearings of the motor. This type of construction requires a minimum amount of attention. Each instrument is supplied with a toggle switch in the motor circuit so that the motor can be stopped at any time, for instance while the mechanism of the instrument is being observed. The motor is held in position by four screws. It is connected to the electrical circuit by a separable coupling so that the motor can be removed from the instrument by merely taking out the four screws.

The flexible shaft which is used as a universal coupling between the motor and kidney cam is made of three layers of wire, wound in opposite directions, with a fitting on each end containing a plate clamp for fastening to the motor and kidney cam shafts. The plate should be clamped tight on the shaft, otherwise backlash in the kidney cam will cause a knock or jump in the step lever.

H. HUMIDITY COMPENSATOR

A humidity compensating strip is used on pen dragging and print hammer type instruments. The position of the pen and print hammer indicates the correct temperature reading and is not affected by changes in humidity. It is known that the best available papers for making roll charts expand or contract as the humidity changes. In order to minimize the effect of this condition, charts are printed under conditions of controlled humidity, insuring uniformity of expansion and contraction among all charts.

On instruments using the ink pen, a humidity compensator has been added to give the highest degree of precision in following the time-temperature curve of a single process. This is shown in Figure 1358-3.

mer in direct proportion to the extent of the expansion or contraction of the chart, without moving the pen carriage. The movement is always proportional to the position of the pen with respect to full scale on the chart because it is accomplished through the angularity of the compensator bar which causes minimum movement at the upper end of the chart where the paper and bar are pivoted and where the least change occurs, and maximum movement at the lower end where the greatest change occurs.

The humidity compensator bar is parallel with the line of travel of the pen carriage and is directly back of the scale plate.

The extent of backward and forward motion of the bar is proportional to the distance from its pivoted end and accordingly the motion of

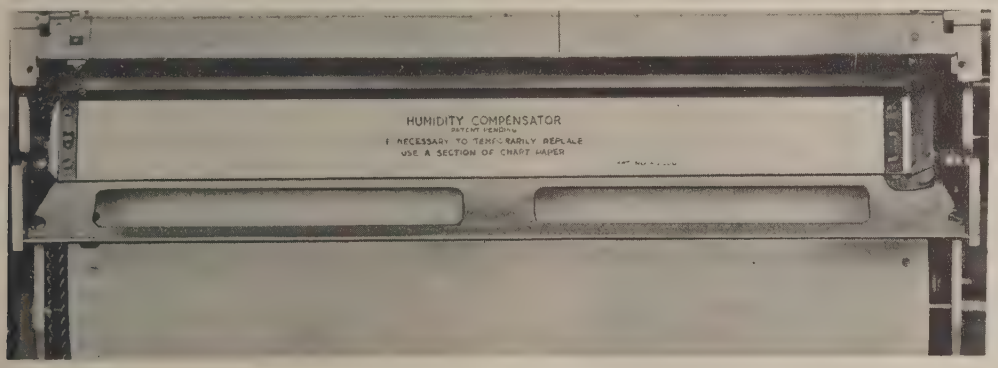


Figure 1358-3
Humidity Compensating Strip

This compensator consists of a strip of paper similar to the chart paper which is fastened at the right-hand side of the instrument, under the writing platen, close to the chart paper and free to move longitudinally at the left-hand side.

When the length of the paper strip changes due to a change in relative humidity, the movement is transmitted by linkage to the compensator bar which is always in contact with a small bell crank lever on the pen carriage.

The humidity compensator strip is held under tension by a small spring on the left-hand end of the compensator bar. The strip and the bar are connected by a simple lever system. A movement of the compensator bar causes a movement of the bell crank lever on the pen carriage, which causes a movement of the pen or print hammer in direct proportion to the extent of the expansion or contraction of the chart, without moving the pen carriage. The movement is always proportional to the position of the pen with respect to full scale on the chart because it is accomplished through the angularity of the compensator bar which causes minimum movement at the upper end of the chart where the paper and bar are pivoted and where the least change occurs, and maximum movement at the lower end where the greatest change occurs.

The humidity compensator bar is parallel with the line of travel of the pen carriage and is directly back of the scale plate.

The extent of backward and forward motion of the bar is proportional to the distance from its pivoted end and accordingly the motion of the bar is equal to the expansion and contraction of the strip chart at all points across the chart. The pen is thus moved the proper distance to insure proper registry between the pen and the chart under all conditions of humidity.

I. CHARTS AND CHART REROLL

Every chart roll is 125 feet long and, at the standard rate of travel found most satisfactory, 2" per hour, the chart will last 31.5 days of continuous day and night operation. The chart is 12" wide with a distance of 11" between the upper and lower lines. Time markings are printed at 2" intervals, while the temperature scale is printed at 3" intervals.

A reroll for the chart paper which will reroll an entire roll of chart paper inside the instrument is supplied in each instrument. The

chart feeds from the driving roll and folds in the bottom of the case when the reroll is not used. When allowed to fold in the bottom of the case, it is only necessary to remove it every two days. Whether the reroll is used or not, 8" of chart paper is visible at all times.

The reroll operates from a chain drive on the left-hand end of the chart drum, through a friction drive onto the reroll tube. This friction drive is provided so that, as the diameter of the rerolled chart increases, a slippage of the friction drive allows the increased peripheral speed to be taken care of so that the reroll does not pull the chart off the pins on the driving drum.

J. PEN CARRIAGE

The pen carriage is provided with either a V spring or a split nut which contains a spiral thread which rides in the V notch of the spiral shaft. The split nut takes up all play so that back lash can not develop.

The cradle which holds the glass pen is held in place by V notches in the pen carriage. These notches allow the pen to be removed easily. The notches also act as pivots. They are on the axis of the ink container so that the pen pressure on the chart does not vary with the quantity of ink in the pen. They also insure the pen registering with the proper chart line when the pen is replaced after filling. When the pen carriage moves to the upper end of its travel, the pen should be in register with the upper line on the chart. If this registry does not exist, a slight bend of the left-hand end of the pen-holder will remedy this condition, since the cradle into which the glass pen fits is positioned by the groove in the left-hand side. The pen has a glass capillary tube from the reservoir to the tip. The tip is a piece of platinum capillary tubing.

The reservoir holds sufficient ink for at least 20 to 30 days use, depending on the kind of record that is being made. The amount of ink remaining in the pen is visible at all times. The ink is quick drying and can be furnished in red.

K. PRINT HAMMER MECHANISM

The print hammer which makes a single dot on the chart, can be fitted with a stylus which produces a dot inside of a circle. The large circle dot record is easier to read from a distance. If the print hammer does not strike the ribbon properly it can be bent to do so.

The print hammer carriage slides on the humidity compensating bar and is moved up and down scale by means of a split nut on a spiral shaft. Wear of the threads and backlash is taken up by a spring which keeps a slight pressure on the split nut.

When the print hammer lever rises on, then drops off a tooth on the color cam ratchet, the print hammer is released, dropping and making a mark on the chart through the colored ribbon.

L. PRINT WHEEL MECHANISM

The print wheel rotates in a plane parallel with the temperature divisions on the chart. Any inaccuracy in the indexing (which is not likely) cannot affect the accuracy of the temperature record; it will merely introduce a slight error in the time record of the character being printed.

Because the purple ink pad has a much longer life than any other color, it is used on instruments printing all records in a single color. This is felt to be a distinct advantage from the maintenance standpoint. The purple ink pad wheel is interchangeable with the multi-color ink cartridge wheel, on 2 to 12 record instruments; above 12 records only a solid color wheel can be used. It is possible to change from one to the other in the field, if desired.

Driving gears, etc. do not need to be removed, and accordingly require no retiming after changing the print wheel or the ink pad wheel.

TABLE SHOWING THE COLORS ON MULTI-COLOR PRINT WHEELS

No. of Records	Switch Point Number											
	1	2	3	4	5	6	7	8	9	10	11	12
2	GREEN	RED										
3	GREEN	RED	PURPLE									
4	GREEN	RED	PURPLE	BLUE								
5	GREEN	RED	PURPLE	BLUE	BLACK	BROWN						
8	GREEN	RED	PURPLE	BLUE	BLACK	BROWN	GREEN	RED				
12	GREEN	RED	PURPLE	BLUE	BLACK	BROWN	GREEN	RED	PURPLE	BLUE	BLACK	BROWN

M. THERMOCOUPLE BURN-OUT SAFETY FEATURE

A thermocouple burn-out safety feature can be provided on a single record controller. This feature operates as follows: when the thermocouple burns out, the galvanometer circuit is opened. The galvanometer pointer assumes a predetermined position below the normal neutral which causes the pen carriage to move upscale. When the pen passes the control point, the furnace is automatically shut down until the burned out thermocouple is replaced. A red arrow is engraved on the step table .040" below or to the left of the black arrow at the center of the neutral step. The mechanica and electrical zeros are then adjusted to bring the pointer to this red arrow position. The secondary pointer, however, has not been changed and still contacts the neutral step of the step lever when the pointer is at the black arrow on the step table. The .040" distance between the middle of the neutral step and the red arrow may be either two or three steps below the neutral step, depending upon the slope of the step table.

If the thermocouple burns out, the galvanometer circuit is opened and the pointer swings to its mechanical zero position at the red arrow. This causes the secondary pointer to contact the step lever two or three steps above or away from the neutral step on the step lever, which causes the drive pawls to move the large spur gear to give the pen an upscale motion. This motion continues until the pen reaches the upper limit of its travel. In its travel, it passes the control index whereupon the control shuts off the furnace. The slidewire contact, meanwhile, has been moved with the pen, but since the galvanometer circuit is open, the position of this contact is immaterial. When a new thermocouple is connected properly, the instrument operates as usual at the black arrow balance step, which means that the electrical system is displaced .040" from its zero position. When the thermocouple burnout safety feature is used, the linear shift or pointer displacement is taken care of in calibration by adjusting the No. 8 spool. The resistance of the No. 1 spool, which is a shunt around the galvanometer, is also increased (depending upon the millivolt span) to give greater damping of the galvanometer on open circuit. This damping causes the pointer to settle down more rapidly to its mechanical zero if the thermocouple burns out so that the pen carriage can begin to move upscale at once to shut off the furnace. The No. 1 spool (see Dwg. D-2209) which without burn-out feature, is only in the circuit when the standardizing switch is moved, is now connected permanently in the circuit by a connection from the top stud of the No. 1 spool to a short stud provided for this purpose.

N. MERCURY SWITCHES

The mercury switch is a hermetically sealed glass enclosure, usually cylindrical in shape, containing a quantity of mercury, an atmosphere of hydrogen gass or a vacuum, and either two or more electrodes, or provisions for dividing the mercury into separate pools. Due to its liquid nature and electrical conductivity, the mercury will make or break an electric circuit when the switch is tilted from the horizontal position. The mercury switches are used to operate relays controlling valve action or heater loads. If the load is small enough to be handled by the mercury switch, relays are eliminated, which reduces the amount of wiring and the danger of trouble from extra contacts, and eliminates all danger of corrosion at the contacts as well as danger of explosions in the presence of explosive vapors, fumes, etc. The mercury switches can be used to operate signal lights if desired, instead of a valve.

There are certain precautions which must be observed if entirely satisfactory results are to be obtained from the mercury switches.

1. Switches must not be overloaded. Ratings given are maximum ratings and should not be exceeded.

2. Proper external leads must be used. Also, the leads to the switches should not be changed. If the leads are too small, they become overheated and this heat is transferred to the seals of the switch, resulting in damage to the tube.

3. Switches supplied by other manufacturers should not be substituted for those supplied by The Brown Instrument Company. Mercury switches are of two distinct types, "snap action" and "slow action". It is most important that snap action switches be used where there is a definite snap on and off action. They must not be used for slow acting applications such as thermostats. Switches marked slow action or not marked, may, in general, be used on either type of action.

4. Note that the ratings given in the specifications for each switch are for heater, or non-inductive loads. These ratings do not apply to inductive loads, such as coil, or motor loads. Such a load has a high rush current and a high kick-back current when the circuit is broken. For this reason, the inductive load which any particular mercury switch will handle is considerably smaller than its heater or resistance load rating. Ratings are given in the Mercury Switch Specifications Table on the following page.

MERCURY SWITCH SPECIFICATIONS

ITEM NUMBER	PART NUMBER		SWITCH RATING A-C OR D-C AMPERES NON-INDUCTIVE LOAD		DESCRIPTION	LENGTH OF LEADS
	BROWN	M-H	125V	250V		
1	15533	H-169-3	25	20	On-off, 2 electrodes, Mercury to Mercury Contact	16
2	15653	C-465-12	10	5	On-off, 2 horizontal electrodes at one end, Mercury to Metal Contact	24
3	15748	C-640-2	5*	3*	3-position 5 electrodes, 1 Mercury to Metal Contact in each position.	20
4	17126	C-636-2	5*	3*	3-position 4 electrodes, Mercury to Metal Contacts no contacts on neutral.	18
5	74793	H-172-2	45	35	On-off, 2 electrodes, Mercury to Mercury Contact	12

Rating for a-c only. On d-c the rating is 3 amps. @ 125 Volts or 1.5 amps. @ 250 Volts (non-inductive load).

The above ratings are the capacity of the mercury switches only and are listed for purposes of identifying the mercury switches. These will differ from the nameplate rating. This is due to the limitations of the control cables which are rated at 5 and 25 amps. However, it is possible to combine cables of any capacity, such as combining two 25 amp. cables for up to 50 amps. In any case the limiting capacity of the control circuit of any instrument is always the rating stamped on the instrument nameplate.

SECTION 1359
Issue 2

MECHANICAL ADJUSTMENTS AND CORRECTIVE DATA

The Brown Type 113 Potentiometer Pyrometer and Resistance Thermometer

This section covers the mechanical adjustments and corrective data which, when followed, will make servicing of these instruments easier.

A. PEN

B. PRINT WHEEL MECHANISM

C. PRINT HAMMER

D. THERMOCOUPLE SWITCHES

E. CHART FEED ADJUSTMENT

F. HUMIDITY COMPENSATOR ADJUSTMENT

G. CHECKING THE CALIBRATION (Mechanical Adjustments)

H. TIME CYCLE ADJUSTOR

I. STEP LEVER ADJUSTMENT

J. GALVANOMETER ADJUSTMENTS

K. PAWL SELECTOR LEVER

L. VIBRATION OF KIDNEY CAM

M. REPLACING MOTOR CAPACITORS

N. SLIDEWIRE

A. PEN

If the pen is replaced on a single record instrument the instrument should be checked for mechanical calibration.

Proceed as follows: Run the pen upscale, if the pen point does not stay on the last chart line bend the left-hand end of the pen holder either forward or backward until the pen point is in register with the upper chart line.

To start the ink flowing tilt the pen point downward 45°, at the same time work pen cleaning wire in capillary to wet capillary tube which will assist the ink in flowing to the point. Withdraw the wire slowly.

If there are air bubbles trapped in the glass capillary, the pen will cease to write. When this occurs, place finger over the filling hole and hold in palm of hand or in warm water until the ink starts to flow.

If there is dirt in the capillary, the ink will not flow. In such cases, wash pen out in clean, warm water.

B. PRINT WHEEL MECHANISM

1. Ink Pads

When the printed characters on the chart become faint, the ink pad (or pads) requires re-inking, reversing, or replacing.

a. Re-inking: Apply ink (of proper color) to the pad, at the rate of a drop or two at a time, until the pad cannot absorb more ink. Use the applicator supplied with the bottle of ink. Remove excess ink with a blotter. On multi-colored instruments, care must be used so that excess ink on one pad will not run over to the adjacent pad.

NOTE: All 16-record instruments and single color printing recorders require PURPLE INK.

b. Reversing: If ink pad becomes worn it may be reversed in position so that the end formerly under the metal cap of the ink wheel assembly is exposed for making contact with the numeral wheel.

Refer to Fig. 1359-1. Unscrew the thumb nut and remove the complete ink pad wheel from the instrument. The metal cap can then be slipped off, exposing the felt ink pads. Remove each pad (or the one pad for single color instruments) and replace it in the same slot with its position reversed, so that a new surface is under the printing characters. Slip the metal cap over the ends of the pads and the moulded form. Replace the assembly onto the print wheel carriage of recorder insuring that the knob on the moulding enters the slot on the gear assembly. Replace the thumb nut and tighten firmly by hand.

c. Replacing: When both ends of a pad become worn it is necessary to replace them with new pads. The replacement is done in same manner as "Reversing" except that new pads are inserted.

2. Print Wheel Adjustment

After some months of service, the print wheel may need a minor adjustment to insure printing of full characters. Need for adjustment is indicated by the printing of the top or bottom of the character, thus +° or + ⌐ instead of +2.

To correct this condition, stop the instrument and proceed as follows, referring to Figure 1359-1.

a. If upper part only, of numeral is being printed, loosen set screw B and tighten set screw A on the spur gear and hub assembly.

Rotate the printing cam and ratchet assembly on the right-hand side plate until a numeral is printed. If sufficient adjustment has not been made, repeat until printing is correct.

b. If lower part only, of numeral is being printed, loosen set screw A and tighten set screw B on the spur gear and hub assembly.

c. Rotate the printing cam and ratchet assembly until a numeral is printed. If sufficient adjustment has not been made, repeat until printing is correct.

NOTE: Make sure that both set screws A and B are tight when the final adjustment is made.

C. PRINT HAMMER

1. Print Hammer Adjustment

The print hammer, which makes a single dot on the chart can be fitted with a stylus which produces a dot inside of a circle. The large circle being easier to read from a distance.

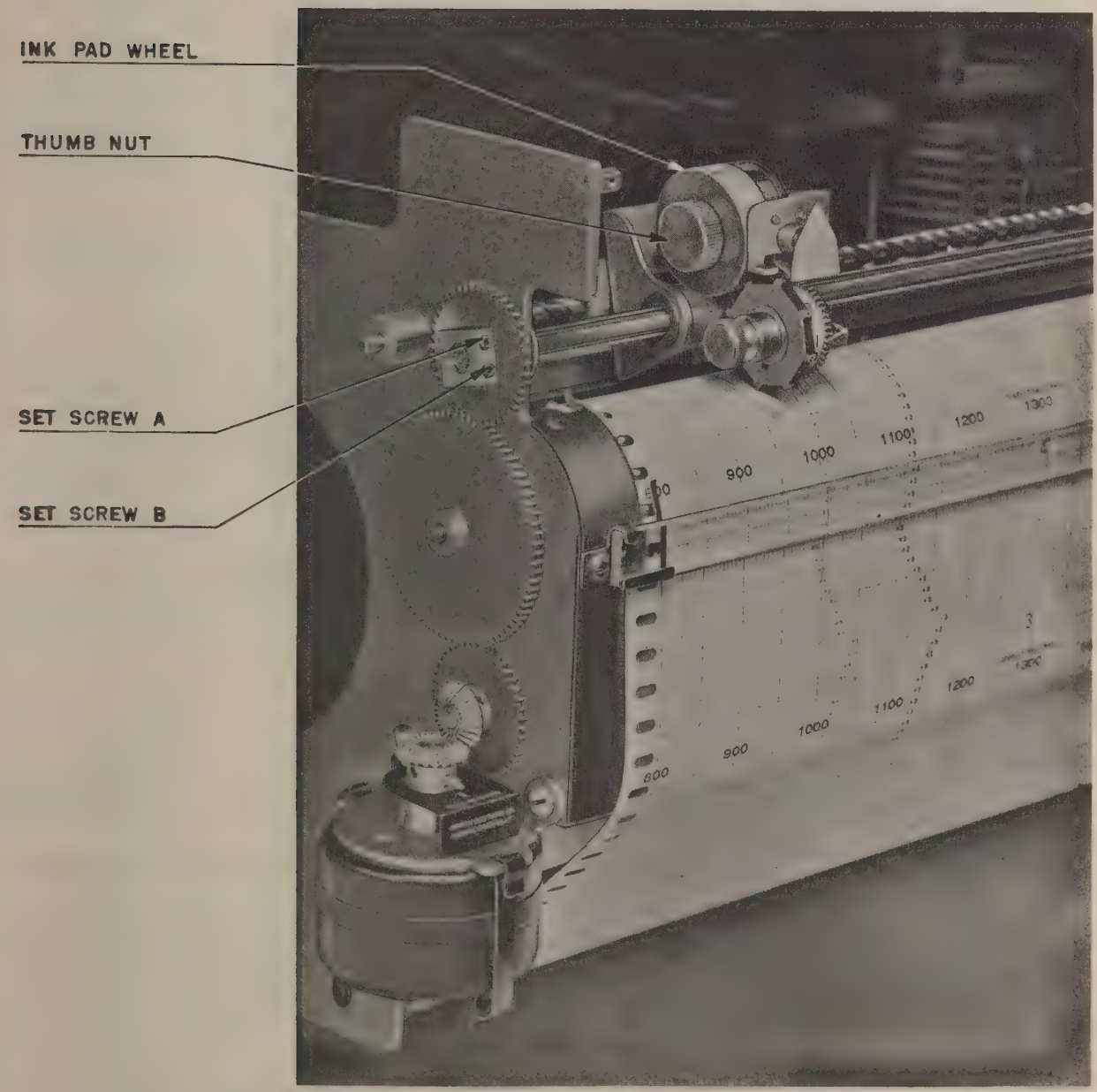


Figure 1359-1
Left-Hand Side Plate of
Print Wheel Instrument

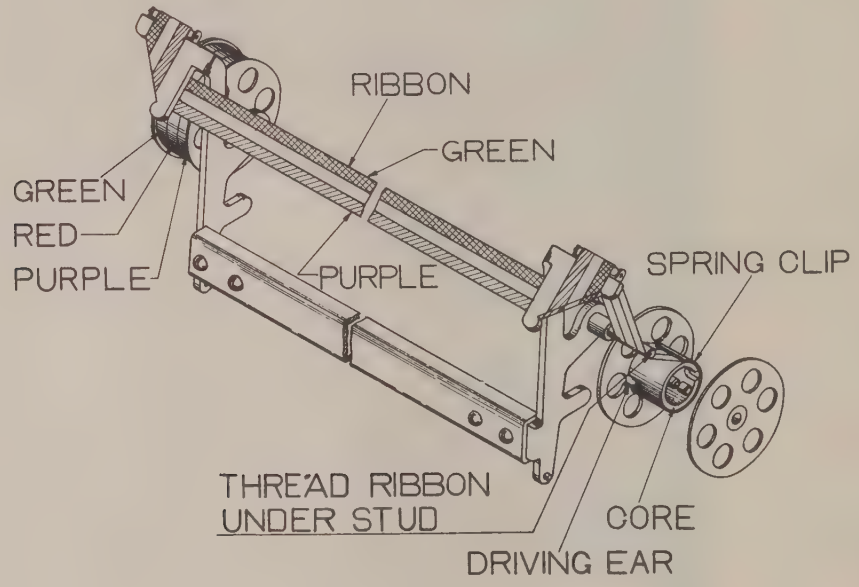
If the print hammer does not strike the ribbon properly it can be bent to do so.

2. Replacing Multi-Colored Ribbon

The multi-colored ribbon reroll is driven from the chart drum through a spur gear. The ribbon is rerolled in direct proportion to the speed of the chart roll; that is, the ribbon will run out about one day after the entire chart has run through. The ribbon should be renewed at the same time the chart is renewed.

driving gear engages into the slot in the core. Then snap the guide disc onto the right-hand ribbon stud. The slack in the ribbon can now be taken up by turning the left-hand ribbon spool by hand until the ribbon is tight.

The supply ribbon reel has been provided with a friction spring which applies the proper friction to prevent the ribbon from curling. It is very important that the ribbon be renewed after having been run through once.



Drawing 16-G-15
Ribbon Assembly on Print Hammer Potentiometer

Charts and ribbons should be ordered in equal quantites for multiple recorders. For the ribbon specify part number 15270.

To renew the ribbon, remove outer ribbon guide discs which are held in place by snap action. Remove the used ribbon from the right-hand side, and retain only the empty core and clip. The new ribbon must be placed on the left-hand ribbon stud, purple side first; then snap the left-hand guide disc into place. Attach the used core to the end of the ribbon by means of the spring clip shipped with the new ribbon.

Wind up about a turn clockwise, thread the ribbon over the ribbon carrier and under the stud as shown in Drawing 16-G-15, and slip the core on the right-hand ribbon stud with the purple side next to the instrument, making sure that the

D. THERMOCOUPLE SWITCHES

1. Oil Switch Adjustment on Print Wheel Instruments

If, for any reason, it becomes necessary to remove the entire oil switch assembly or replace any of the parts in the printing or switching mechanism, it will be necessary to set the switch in correct relation to the print wheel so that thermocouple number 1 is connected at the time figure 1 is printed.

To make this adjustment, stop the instrument, refer to Figure 1359-2 and proceed as follows:

a. See that the printing cam and ratchet assembly, and the geneva gear are in locked position.

b. Remove cotter from the spur gear and remove the gear.

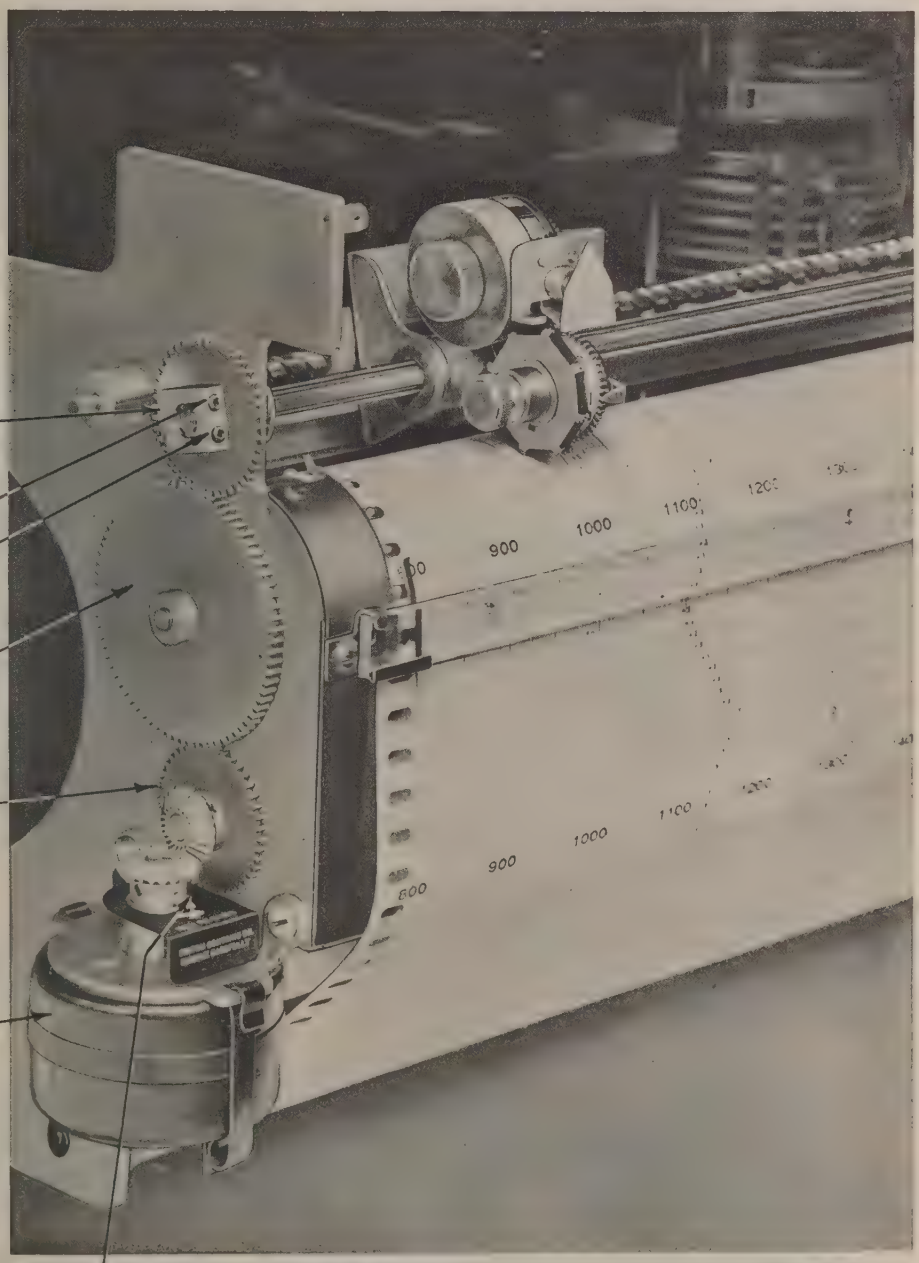


Figure 1359-2
Thermocouple Selector Switch and Printing Mechanism - Left-Hand Side Plate of Print Wheel Instrument

c. Loosen the set screws in the mitre gear and spur gear assembly and rotate the gear on the oil switch assembly until the small projecting pointer on the vertical shaft of the oil switch is in alignment with the mark on the top of the switch, labeled No. 1 Record. Refer to Figure 1359-2.

d. Tighten the set screws in the mitre gear and spur gear assembly.

e. See that set screws A and B in the spur gear and hub assembly are tight and flush with the side of the square hub (in their mid-position).

f. Rotate the spur gear until the numeral 1 on the record indicating wheel is directly under the index on the front of the print wheel carriage assembly.

g. Replace the idler gear and cotter being sure not to move the spur gear any more than necessary.

h. Rotate the printing cam and ratchet assembly until a numeral is printed. If the entire numeral is not printed correctly adjust the print wheel as described in this section under paragraph entitled, "Print Wheel Mechanism".

2. Oil Switch Adjustment on Print Hammer Type Instrument

If for any reason it becomes necessary to remove the oil switch or replace any of the parts on the switching mechanism, it will be necessary to set the thermocouple switch in connection relation with the Print Hammer.

To make this adjustment refer to Drawing 16-G-13 and proceed as follows:

a. With the pointer on the indicating dial pointer to record #1 set the thermocouple switch brushes as shown in Drawing 16-G-13 with the brushes farthest away from the shaft on the left side (looking into the bottom of the switch) and line up the right side of the brush mounting screw with the left side of the shaft and the left side of the notch in the cover.

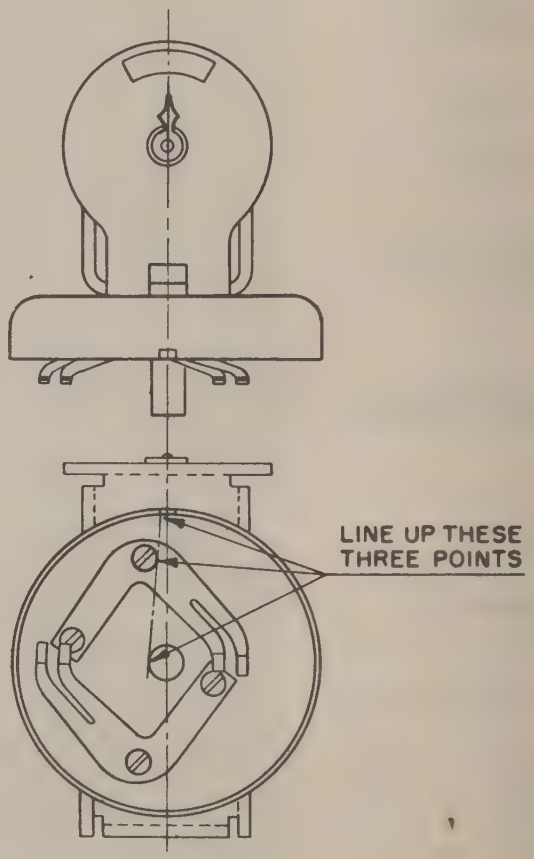
   Tighten the set screws to prevent a change in this relationship.

b. Mount the switch making sure that the print hammer has just printed a green dot and the pointer is on record #1 on the dial.

3. Brush Adjustment

If the brushes have been accidentally bent adjust for proper tension as follows:

Adjust the brush tips to a distance (approximately 15/64") away from the brush holder so that a force of approximately 125 grams will deflect the brushes until the distance between the bottom edge of the switch case and the bottom of the brushes is 5/32".



Drawing 16-G-13

Print Hammer
Brass Contact Type
Thermocouple Switch

E. CHART FEED ADJUSTMENT

Figure 1359-3 shows the adjustable 6-step chart speed arm which governs the number of teeth taken on each stroke of the table cam lever. The speed of the chart can be varied readily by loosening the clamping screw and revolving the step cam until the desired chart speed figure falls underneath the operating lever. The numbers on the cam indicate inches of chart speed per hour. The standard chart speed is 2 inches per hour.

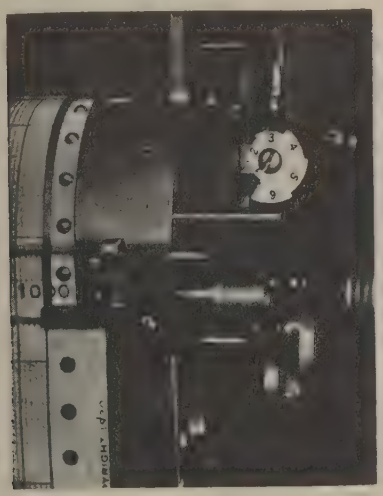


Figure 1359-3
Chart Speed Cam

If the chart speed is not correct check the frequency of the motor or the action of the latching pawl on the ratchet. A one tooth movement of the ratchet will give a 1 inch per hour chart speed.

F. HUMIDITY COMPENSATOR ADJUSTMENT

In case of excessively rough handling the humidity compensator strip may be torn. This can be readily observed by noting that the pen or print hammer is far out of register with the index on the scale. Also, in making an effort to adjust the humidity compensator by means of the screw, reached through the small hole to the right of the chart, shown in Figure 1359-3, there will be no response. To replace the strip, remove the writing platen by removing the two lower screws (one of these is shown in Figure 1359-3) on the chart clips at the tear-off glass. Remove the cotter at each end of the compensator strip shown in Figure 1359-4 and lift off the paper clamps. After inserting the new compensator strip, replace the paper clamps, attaching them to the paper so that the clamp on the left end is in the center of the elongated hole. The replacement strip can temporarily be a strip of chart cut to the correct width. This should be considered as a temporary measure only. Complete compensator strips with clamps attached are assembled and accurately adjusted at the factory and should be used for best results. Attach the clamps on the studs, the left one first, and replace the cotters. Fasten the writing platen back in position, then adjust the pen position by means of the eccentric screw adjustment.

The location of the eccentric adjusting screw is shown in Figure 1359-4. This adjustment is made when the pen carriage is at the extreme lower end of the scale and the drive gear stops are in contact. The pen or print hammer is then set to register with the lowest line of the chart by turning the adjusting screw.

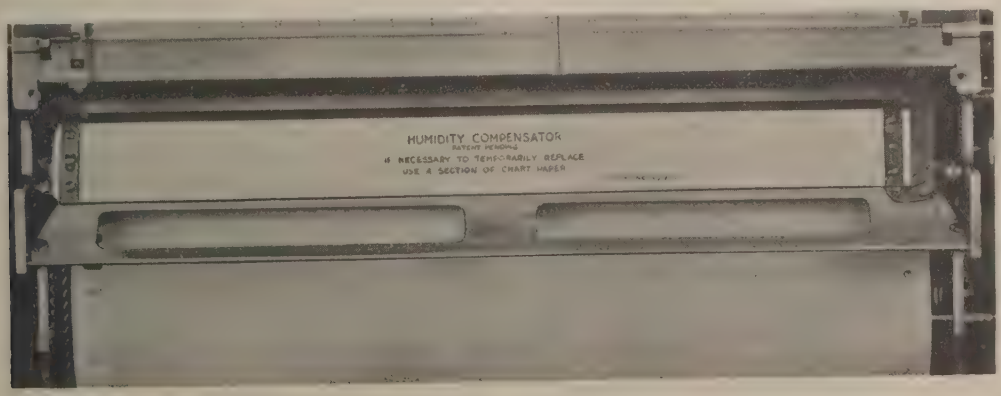


Figure 1359-4
Humidity Compensator Strip

G. CHECKING THE CALIBRATION (MECHANICAL ADJUSTERS)

When the full scale position has been reached, as determined by the gear stops, the pen should register full scale reading on the chart. The pen carriage index should register full scale reading on its scale; the slidewire contact should be at the upper end of its travel, but not striking the clamp on the slidewire winding, and the arrows on the two bevel gears should be in register. If the pen is out of register see that the pen is properly located in the pen holder and hung properly on the carriage. If this does not bring the pen to the correct position, loosen the two set screws attaching the small spur gear to the spiral shaft; turn the spiral shaft by hand to bring the pen to the proper position and tighten the set screws, being sure that the gear stops are engaged and the spiral shaft has no end play, although still free to turn. Then, if the pen carriage index is out of register, loosen the screws holding the scale; slide the scale into register and retighten the screws. Before attempting any adjustment of the bevel gears or the slidewire contact, run the pen to the opposite end of the scale and see that the slidewire contact is at the lower end of its travel, but not striking the lower clamp. If the arrows on the spur gears are in register, loosen the two set screws in the hub of the large spur gear and rotate the bevel gear so that after tightening the set screws the upper and lower limits of travel of the slidewire contact will be equidistant from the clamps at the ends of the slidewire. Now, run the pen carriage to the extreme low position to see if the pen, or print hammer, stops exactly on the lowest line on the chart. If the index is correct and the pen or print hammer off, adjust the humidity compensator, as described in this section under paragraph entitled, "Adjusting the Humidity Compensator".

H. TIME CYCLE ADJUSTER

Only the Print Hammer Potentiometer has this adjuster. By the use of the small adjustable numbered cam (shown in Figure 1359-5), the maximum printing cycle of the instrument can be set from six to twenty strokes. The advantage of this feature on a multi-point controller where the controlled temperatures are reasonably close together is obvious, as only a few strokes are required to reach the balanced position and pass over to the next point. This is valuable where time is an important factor in obtaining close control.

If the instrument prints before it comes to balance, check for friction or dirt between the balanced and unbalanced sectors.

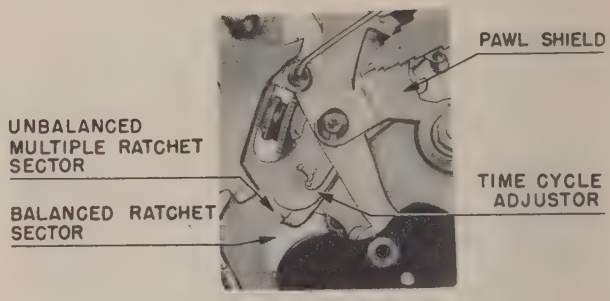


Figure 1359-5
Time Cycle Adjustor

I. STEP LEVER ADJUSTMENT

1. Step Adjustment

After an instrument has been in service for a long time, wear or lost motion might occur between the various moving parts so that when the galvanometer pointer contacts the first step away from the neutral step on the step table and is attempting to come to a balanced position, the motion, in being transmitted from the step table to the spur gear, is not sufficient to move the spur gear through the small distance corresponding to one tooth. In this case, to correct, it is only necessary to take a few light file cuts on the first step off neutral of the main step lever so that it will move farther before being stopped by contacting the secondary pointer. The pawls will then move farther giving the spur gear the necessary one-tooth movement. This will tend to balance the galvanometer deflection by giving the slidewire a new point of contact.

2. Bearing Adjustment

An adjustment is supplied on the step lever as a means of providing the necessary clearance between the pawl selector lever and the secondary pointer. This adjustment is used, if the secondary pointer is prevented by the pawl selector lever from reaching its highest position.

The adjustment is made as follows:

Hold the galvanometer pointer all the way over to the left and then run the kidney cam around until the lowest step on the step galvanometer step table contacts the galvanometer pointer. At this point in the cycle the secondary pointer should be in its highest position. If it contacts the pawl selector lever before reaching its highest position loosen the hex nut and turn the eccentric stud (holding the ball bearing cam follower on the step lever) in either direction until the secondary pointer is free to move into its highest position. Adjust to allow a slight clearance in this position then tighten the hex nut on the eccentric stud and recheck as above. If necessary repeat the adjustment.

J. GALVANOMETER ADJUSTMENT

If the galvanometer pointer rests against either the upper edge or the lower edge of the clamping bar, take off the back cover plate of the galvanometer to see if either suspension is broken. If so, stop the motor when the galvanometer clamping table is in the down position and not contacting the pointer. Then remove the two leads, turn the hold-down clip in a counter-clockwise direction until the clip clears its studs and remove the galvanometer assembly.

After removing the galvanometer unit from the instrument, it should be placed upon a flat surface. The suspension tension is relieved by turning the marked adjusting screws in the back. The broken suspension tips can be readily removed after loosening the small screws in the coil and mounting sockets. The new suspension tips should be carefully inserted to their full depth, using tweezers. Then clamp the tips with the small screws. Care must be taken to see that the suspension ribbon is lying flat and that both zero adjusting arms are in mid-position.

After the suspension is clamped in place, it is drawn tight by turning the adjusting screws two or three turns in the direction indicated by the arrow in the bakelite moulding. This adjustment is not critical. Now hold the galvanometer frame in an upright position. Adjust the bottom zero adjusting arm until the pointer is at right angles to the back of the moulded frame. The galvanometer coil should then be balanced to overcome any effect resulting from the instrument not being mounted in an absolutely horizontal position.

With the suspensions under tension, place the bakelite frame in a horizontal position, lying on its side. If the pointer is not in balance in this position, hold the coil lightly against the cylindrical core and turn the counter-weight on the counterpoise screw. The weight should be screwed out if the pointer falls, and vice-versa. When a balanced condition is obtained, the weight should be about 1/16" from the end of the counterpoise. If a balance can not be obtained because the weight is not heavy enough, turn the bakelite frame on its back, hold the coil in the V notches and push down on the saddle straps (C-D or E-F in Figure 1359-6) with a pair of tweezers until a balance is obtained. This operation bends the suspension tip sockets forward. The sockets are mounted on soft copper saddles so that they can be readily bent.

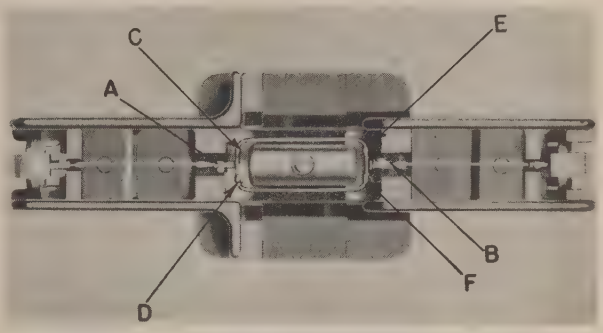


Figure 1359-6
Position of Galvanometer for Replacing Suspensions

The bakelite frame should now be turned over on its back, and the condition of balance noted. If the pointer does not come to a vertical position, but deflects either to one side or the other, adjustments should be made by slightly bending one of the suspension tip sockets (A or B in Figure 1359-6) in the same direction as the pointer deflects. This should be done without releasing the tension. These two tests should be repeated until the system is balanced in both positions. The galvanometer pointer should be approximately in the zero position so that the final adjustment to bring it to zero can be made by means of the zero adjuster. An additional adjustment for zero balance is provided at the bottom end of the galvanometer.

The spring clip to which the top suspension is fastened extends back and upward to contact the gear in the galvanometer cover, which is moved by the zero adjuster screw. Before the cover is replaced, this spring clip should be bent forward to insure having a good contact with the gear.

If the galvanometer pointer sticks to the upper clamping bar, it is caused by the stripper not coming down low enough to free the pointer. To remedy, clean the pointer tip and clamping bar with Carbona or carbon tetrachloride, and bend the ear on the upper right side of the step table downward so that it will bring the stripper bar about 0.025 inch below the clamping bar.

If the step table does not contact with the galvanometer, remove the galvanometer cover and see that the step table rises freely until it contacts the galvanometer pointer. See that the step table is free in its bearings, as any binding at this point would cause a jumping action.

Inspect the phosphor bronze springs which lift the table and see that they are under proper tension. The tension from these springs should

be sufficient to cause the step table to rise at a steady rate. A jerky action of the step table will result in excessive wear of the galvanometer pointer.

If the step table slips off the galvanometer pointer, proceed as follows:

1. Clean galvanometer pointer and steps.
2. If excessive vibration is present, mount the instrument on vibration absorbers.
3. Eliminate all vibration due to misalignment of the step lever or rough cam.
4. Make sure the step table is mounted straight.
5. Make sure the galvanometer pointer is installed with the raised edge left by the blanking die, toward the step table.
6. If step table and galvanometer pointer edges have been worn round they should be replaced. When either of these parts need replacing always replace both the step table and pointer.

K. PAWL SELECTOR LEVER

1. Spring Adjustment

If the pen or print carriage does not move in response to galvanometer deflections, wipe off the faces of the driving pawls. They may be oily. **This is very important.** If this does not correct the trouble, see if the leaf spring on the pawl selector lever causes alternate pawls to be thrown into engagement with the large spur gear when the secondary pointer is moved one step each side of neutral. The instrument should respond properly every time. If it fails to respond, the leaf spring is not set properly. An easy way to make this adjustment is to move the secondary pointer one step off neutral from either side and adjust the drive pawl spring by bending it lightly until it follows the pawl to the end of its travel. It is usually better to remove the large spur gear in making this adjustment. If the main step lever assembly, at the bottom of its stroke, touches the drive pawl spring, correct this condition by giving the main step lever assembly a slight bend, or twist in toward the side plate.

2. Lever Adjustment

It might happen that the very edge of the selector lever tooth contacts with the secondary pointer and vibration might cause the pointer to slip off the edge of this tooth and fall down to the next lower tooth. To correct for this, it is only necessary to make a slight adjustment on the knurled screw on the end of the secondary pointer positioning lever. Turning this knurled screw clockwise will move the secondary pointer down.

L. VIBRATION OF THE KIDNEY CAM

Excessive back-lash in the drive mechanism may be detected by observing the action of the large kidney-shaped cam on the right-hand side plate. This cam should rotate at a uniform angular velocity and should not show any jumping action under the influence of the spring driven step lever. If back-lash is observed, it may be caused by a loosening of the set screw on the flexible shaft, or the motor itself may have developed excessive back-lash in its reduction gearing. The effect of back-lash in the motion of the kidney cam will tend to cause excessive wear on the secondary pointer. Ordinarily, the step lever descends smoothly until one of its steps contacts with the secondary pointer, but in the presence of excessive back-lash there is a sudden impact as the step lever jumps downward. Such a condition should be corrected immediately.

M. REPLACING MOTOR CAPACITORS

1. General

Either the capacitor and/or motor can be replaced.

2. Replacing Motor and Capacitor

a. Turn off power supply.

b. Disconnect the motor lead wires, loosen the flexible shaft clamp and remove the motor from the chassis.

c. If not already there, drill and tap two 10-32 holes in the under surface of the chassis as shown on sketch 16-G-14.

d. Install the new motor on the chassis, connect the lead wires and tighten the flexible shaft clamp.

e. Unfasten the capacitor from the motor by removing the 2 mounting screws. **Do not disturb the capacitor connections.** Fasten the capacitor to the under surface of the instrument chassis with two 10-32, 1/4" machine screws.

f. Test the motor by turning on the power.

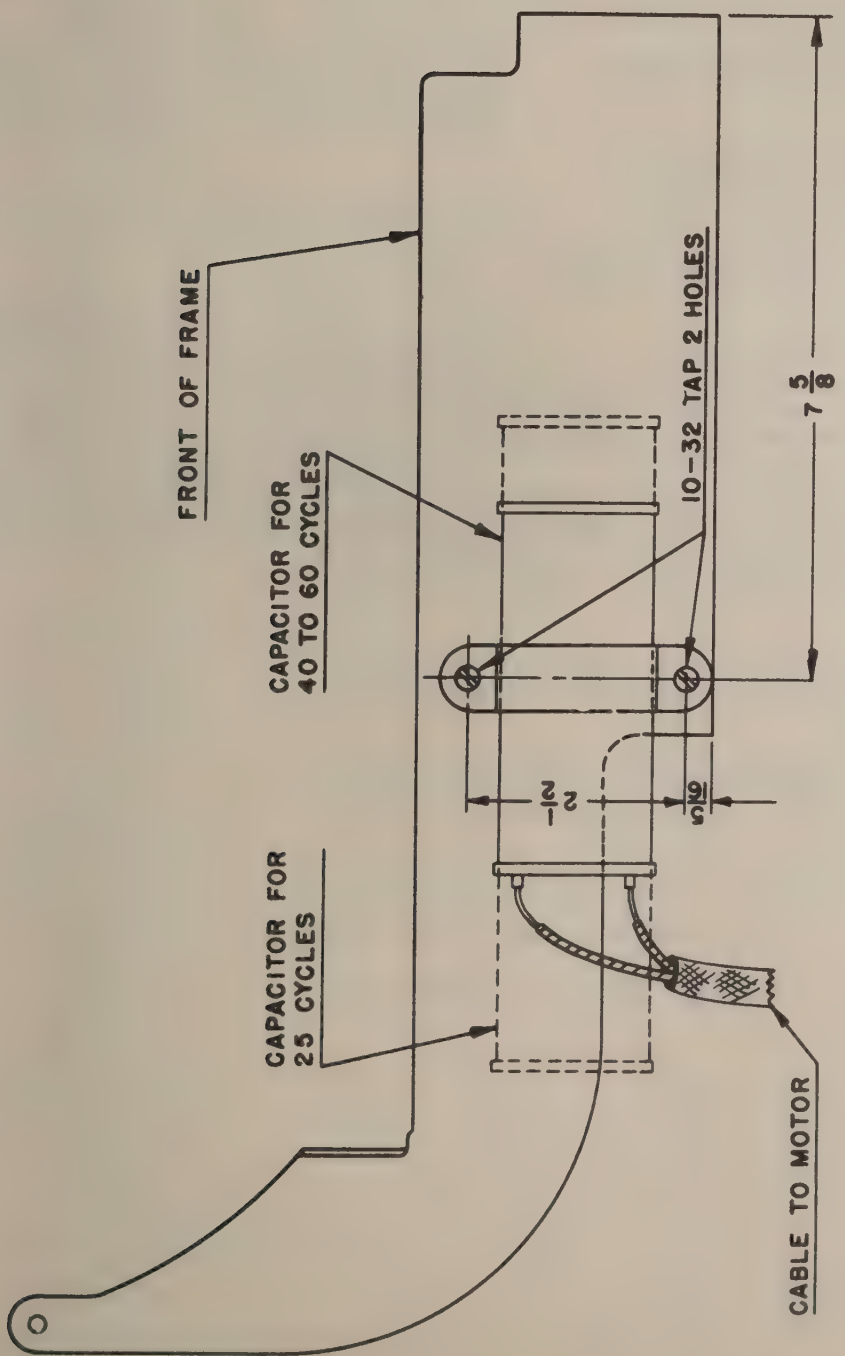


FIG. 16-G-14

METHOD FOR MOUNTING NEW TYPE MOTOR CAPACITOR FOR STRIP CHART POTENTIOMETERS

3. Replacing Capacitor Only

a. Turn off power supply.

b. Disconnect the lead wires from the capacitor at the terminal lugs and remove old capacitor from motor frame.

c. If not already there, drill and tap two 10-32 holes in the under surface of the chassis as shown on sketch 79-S-32.

d. Fasten the new capacitor to the under surface of the chassis with two 10-32, 1/4" machine screws.

e. If the existing leads are too short for the new capacitor location, it will be necessary to splice them to a short length of two conductor #18 B & S gauge, braided covered lamp cord. Solder the joints and apply a layer of rubber, then friction tape the splices in the approved Underwriter's manner. The lead length for a 25 cycle motor should be 9 inches. It should be 11 inches for a 60 cycle motor.

f. Solder the ends of the wires to the capacitor terminal lugs.

g. After soldering, paint the terminals with green insulating cement, Brown Part #75692. **Make certain all live parts are completely covered with cement.** Allow the first coat to dry for 26 minutes and apply a second coat.

h. Test the motor by turning on the power.

N. SLIDEWIRE

The glass jar when it is being replaced should be centered around the slidewire, before the wire bail is fastened. The bail is fastened in position by means of the clamp on the bottom, which applies a force against the bottom of the glass jar. Care should be taken to avoid placing the bail too far toward the back of the jar as the fitting on the right-hand end of the flexible shaft may strike against the bail clip. To remedy this condition, move the glass jar forward so that this can not occur.

SECTION 1360
Issue 2

ELECTRICAL ADJUSTMENTS AND CORRECTIVE DATA ON THE BROWN TYPE 113 MECHANICAL POTENTIOMETER AND RESISTANCE THERMOMETER

This section covers the Electrical adjustment and corrective data which when followed will make servicing these instruments easier.

A. MEASURING CIRCUIT OF POTENTIOMETER PYROMETER

B. MEASURING CIRCUIT OF RESISTANCE THERMOMETER

C. CHANGING THE RANGE

D. CHECKING CALIBRATION (Mechanical Adjustments)

E. CHECKING CALIBRATION OF POTENTIOMETER PYROMETER (Electrical Adjustment)

F. CHECKING CALIBRATION OF BALANCED WHEATSTONE BRIDGE RESISTANCE THERMOMETER (Electrical Adjustments)

G. GALVANOMETER SENSITIVITY ADJUSTMENT

H. SET THE MECHANICAL ZERO

I. STANDARDIZE THE BATTERY CURRENT

A. MEASURING CIRCUIT OF POTENTIOMETER PYROMETER

If the galvanometer pointer deflects to the left, and it is impossible to bring it to the zero or balanced position with the standard cell balancing switch in the "BAL" position and the rheostat set in either the maximum or minimum position, the battery may require renewal or there may be a poor connection in the battery circuit. See that the battery binding posts are tight. If this does not correct the trouble, install a new battery. Another possibility is that the battery polarity may have been reversed. See that the nine screws at the rear of the slidewire unit are tight.

If the galvanometer is stable, and the instrument draws a straight line without any deviation, the external circuit may have a very high resistance, or may be open.

If the galvanometer pointer swings erratically with the balancing switch in the "RUN" position, it is an indication that there is:

1. A high resistance or break in the thermocouple circuit.
2. The thermocouple may be burned out.

Check the thermocouple circuit and make sure that all connections are tight. Check the connections at the galvanometer binding posts. If this does not correct the trouble, clean the standard cell balancing switch.

To clean the switch, remove the two screws holding the switch cover in place and rub the contact surfaces with a piece of cloth. Coat with vaseline and replace the cover.

When the galvanometer deflects hard to either side with the standard cell balancing switch in the "RUN" position, it is an indication that the temperature of the couple is above or below the temperature range of the instrument, or that the couple or leads have been short-circuited or reversed.

If the record is scattered:

1. Inspect the thermocouple circuit for loose connections.
2. Possibly the thermocouple is badly deteriorated and has introduced a very high external resistance.
3. Check for excessive vibration which can usually be noted when the galvanometer pointer fails to come to rest before it is clamped. The effect of the vibration can usually be corrected by adjusting the tension on the galvanometer suspensions. In extreme cases, mount the instrument on a vibration absorbing mounting.
4. The slidewire may need cleaning. Proceed as indicated under section entitled, "Maintenance".
5. In multiple type instruments, it may be necessary to clean the multiple switch. To clean proceed as indicated under section entitled, "Maintenance".

B. MEASURING CIRCUIT OF RESISTANCE THERMOMETER

NOTE: Do not use Magneto to detect bulb or instrument failure. Use dry cell and buzzer.

If the instrument fails to operate: (Draw a straight line - recorder; or galvanometer does not deflect when scale is rotated - indicators),

1. Battery circuit may be open. Check the battery connections and battery leads.
2. The "C" leads to the bulb may be open. Check the circuit, if the "C" lead on one bulb connected to a multiple recorder is open, the instrument will fail to record the temperature of that particular bulb.
3. The key switch may not be depressed - indicators.

If a record is produced, but the pen moves upscale on a decrease in temperature at the bulb, and vice versa, the battery connections are reversed. Check the polarity of the connection and reverse, if necessary.

If the instrument produces a record at the lower edge of the chart - recorders; or tries to balance at a point below the lower end of the scale - indicators:

1. The bulb may be at a temperature lower than the minimum range of the instrument.
2. If the temperature at the bulb is known to be within the range of the instrument.

a. The lead from the "B" terminal to the bulb may be open, or the "A" & "B" or "A" & "C" leads may be reversed. Check the connections against the circuit diagrams.

b. A portion of the bulb winding may be short circuited. Replace the bulb with one known to be in good condition.

c. There may be a short circuit between the leads from the bulb to the "A" & "B", or the "A" & "C" terminals. Locate and clear the short circuit.

If the instrument produces a record at the upper edge of the chart - recorders; or tries to balance at a point above the upper end of the scale - indicators:

1. The bulb may be at a temperature higher than the maximum range of the chart.

2. If the temperature of the bulb is known to be within the range of the instrument, the lead from "A" terminal to the bulb may be open, or the bulb may be open-circuited. Check the circuit through both.

If a recorder produces a record line which consists of a number of pronounced steps, or an indicator fails to give sufficient response to variations in dial setting the sensitivity is too low.

1. If the cells are new, check the connections and number required in case more than two are needed. The cells may be incorrectly connected together, or too few cells may have been installed.

2. If the cells have been installed for some time, they have probably become exhausted. Renew the cells.

If a recorder produces a record which oscillates back and forth, never reaching a balance, even though the temperature is reasonably constant, or if on an indicator, the galvanometer pointer moves too far for small changes in dial setting, the sensitivity is too high. If the cells have just been installed or replaced, too many have been used. Check the number of cells required.

If the record is scattered:

1. Inspect the bulb circuit for loose connections.

2. Possibly the bulb is badly deteriorated and has introduced a very high external resistance.

3. Check for excessive vibration, which can usually be noted when the galvanometer pointer fails to come to rest before it is clamped. The effect of vibration can usually be corrected by adjusting the tension on the galvanometer suspensions. In extreme cases, mount the instrument on a vibration absorbing mounting.

4. The slidewire may need cleaning. Proceed as indicated under section entitled, "Maintenance".

5. In multiple type instruments, it may be necessary to clean the multiple switch. To clean switch proceed as indicated under section entitled, "Maintenance".

C. CHANGING THE RANGE

First, stop the motor in a position so that the driving pawls are not engaged. Then turn the main driving gear so as to bring the pen and slidewire contact to the full scale stop position. This will bring the arrows on the large bevel gears together. Then loosen the nine small screws in the terminal block on the back of the slidewire unit and by removing the two screws on the top of the slidewire assembly the entire unit can be lifted out. In placing the new slide assembly into the instrument, first turn the bevel gear on the slidewire assembly so that the slidewire contact reaches its upper stop position, and with the pen in its full scale stop position, place the new slidewire in position with the arrows on the two bevel gears together, replace and tighten the screws. For best operation use fresh oil in new slidewire.

Now change the chart and scale, loosening the scale mounting screws, and lift up. If the change of range parts includes a new galvanometer table step, change this by springing the old table out and installing the new one. This is done most readily with the table in its highest position. If a new galvanometer is supplied, this must also be changed. On Potentiometer Pyrometers, change the cold junction compensation spool, which is mounted on the terminal plate and marked "C.J.". See section entitled, "Description of and Data on Component Parts of Type 113 Mechanical Potentiometer", for correct C.J. spool, galvanometer, and step table.

D. CHECKING THE CALIBRATION (MECHANICAL ADJUSTMENTS)

When the full scale position has been reached, as determined by the gear stops, the pen should register full scale reading on the chart. The pen carriage index should register full scale reading on its scale; the slidewire contact should be at the upper end of its travel, but not striking the clamp on the slidewire winding, and the arrows on the two bevel gears should be in register.

If the pen is out of register see that the pen is properly located in the pen holder and hung properly on the carriage. If this does not bring the pen to the correct position, loosen the two set screws attaching the small spur gear to the spiral shaft; turn the spiral shaft by hand to bring the pen to the proper position and tighten the set screws, being sure that the gear stops are engaged and the spiral shaft has no end play, although still free to turn. Then, if the pen carriage index is out of register, loosen the screws holding the scale; slide the scale into register and retighten the screws.

Before attempting any adjustment of the bevel gears or the slidewire contact, run the pen to the opposite end of the scale and see that the slidewire contact is at the lower end of its travel, but not striking the lower clamp. If the arrows on the spur gears are in register loosen the two set screws in the hub of the large spur gear and rotate the bevel gear so that after tightening the set screws the upper and lower limits of travel of the slidewire contact will be equi-distant from the clamps at the ends of the slidewire. Now, run the pen carriage to the extreme low position to see if the pen, or print hammer, stops exactly on the lowest line on the chart. If the index is correct and the pen or print hammer off, adjust the humidity compensator, as described in section entitled, "Mechanical Adjustments and Corrective Data".

E. CHECKING CALIBRATION OF POTENTIOMETER PYROMETER (ELECTRICAL ADJUSTMENTS, INSTRUMENTS WITH CHECKING TERMINALS)

Potentiometer pyrometers furnished with checking terminals can be checked easily from the front of the instrument. This greatly simplifies the procedure, especially when the instrument is mounted flush on a panel board with conduit connections.

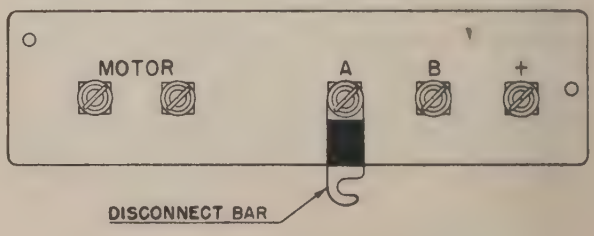
IMPORTANT: The terminal block and cold junction compensating resistor on this instrument are so designed that the temperature will be equalized between each pair of extension lead terminals and the resistor. In order to permit the checking thermometer to assume the correct cold junction temperature, leave it in place at least fifteen (15) minutes before taking a reading.

This is especially important if the thermometer is at a temperature considerably different from the cold junction temperature at the time it is inserted.

Where it is necessary to check a number of instruments, the use of several thermometers will permit their insertion for a long enough time to avoid delaying the work, while they are assuming the correct temperature.

To check the instrument, proceed as follows:

1. Open the instrument door.
2. Place a mercury-in-glass pocket thermometer in back of the terminal plate (either lay the thermometer on the cable or fasten with tape).
3. Loosen binding posts marked A and B, located on the motor lead terminal plate. Allow red connecting bar to hang loose.
4. Connect a low resistance portable potentiometer of known accuracy (Brown Model 126W3V) to terminals B and + shown in Dwg. 16-G-16.



Drawing 16-G-16
Checking Terminal Plate

5. Set the mechanical zeros and standardize the battery currents of both instruments.

6. Read the cold junction temperature on the thermometer. Determine the millivolt equivalent of the temperature at which it is desired to check the instrument and set the "Millivolt" knob and dial of the portable instrument to this value.

7. Set the key switch on the portable potentiometer to the "Zero" position.

8. Allow the instrument to balance.

EXAMPLE: **A calibration check is desired at 1450°F on a potentiometer calibrated 0 - 2000°F M.A. thermocouple. The cold junction temperature is 70°F. From the M.A. temperature-millivolt table based on 32°F cold junction, we find that 1450°F = 32.80 millivolts and 70°F = 0.84 millivolts. The setting of the portable instrument should be the difference between the two values, 32.80 - 0.84 = 31.96 millivolts.**

If it is desired to measure the emf of the thermocouple, connect the portable potentiometer to terminals A and + shown in Dwg. 16-G-16.

The cold junction temperature is read, as before, from the thermometer inserted into the hole provided for it.

On multiple record instruments it is necessary to stop the instrument when the thermocouple switch is connected to the desired thermocouple as shown by the record indicating wheel.

NOTE: **Always replace the red connecting bar and tighten the three binding posts A, B, and + when checking is completed.**

F. CHECKING CALIBRATION OF BALANCED WHEATSTONE BRIDGE RESISTANCE THERMOMETERS (ELECTRICAL ADJUSTMENTS, INSTRUMENTS WITH CHECKING TERMINALS)

Balanced Wheatstone Bridge Resistance Thermometers furnished with checking terminals, can be checked easily from the front of the instrument. This greatly simplifies the procedure, especially when the instrument is mounted flush on a panel board with conduit connections.

To check the instrument, proceed as follows:

1. Open the instrument door.

2. Loosen binding posts marked A and B, located on the motor lead terminal plate. Allow red connecting bar to hang loose.

3. Connect a laboratory type resistance box of known accuracy to terminals B and + of Fig. 16-G-16. This resistance box should be provided with settings to 0.1 ohm.

4. Set the mechanical zero of the instrument.

5. From the table of temperature-resistance equivalents for the Brown resistance thermometer bulb, determine the equivalents of the temperature at which it is desired to check the instrument, and set the resistance box to this value.

6 Allow the instrument to balance.

If the resistance of the leads to each bulb is known, it is possible to measure the resistance of the bulb by proceeding as follows:

1. Connect a Wheatstone bridge of known accuracy to terminals A and + of Fig. 16-G-16

2. Measure the resistance of the bulb, including two leads, and then reverse the connections at the terminals of the Wheatstone bridge and take a second reading. Call the first reading X and the second Y. The meaning of these two readings is equal to the resistance of the bulb plus two leads to the bulb.

Bulb resistance $= \frac{X + Y}{2}$ **- Resistance of two leads to bulb**

3. The temperature of the bulb corresponding to its resistance is given in the table referred to above.

4. On multiple record instruments it is necessary to stop the instrument when the bulb switch is connected to the desired bulb as shown by the record indicating wheel.

NOTE: **Always replace the red connecting bar and tighten the three binding posts, A, B, and + when checking is completed.**

G. GALVANOMETER SENSITIVITY ADJUSTMENT

When leaving the factory, the sensitivity is adjusted for average conditions of external resistance and vibration. When an adjustable galvanometer sensitivity resistor is supplied and if installation conditions differ from this average, adjust the sensitivity as follows:

The sensitivity adjustment should be made to provide maximum sensitivity without overshooting. If the instrument overshoots when coming into balance, the galvanometer is oversensitive and the terminal B should be moved clockwise around the adjustable resistor, Fig. 1360-1. If the instrument requires a large number of steps to get into balance, the galvanometer is undersensitive and the terminal B should be moved counter-clockwise around the adjustable resistor. In relocating movable terminal B, loosen the small set screw with a jeweler's screw driver and retighten it securely on the new terminal. Care should be taken to see that terminals are not short circuited by being bent together.

H. SET THE MECHANICAL ZERO

While the motor is running, push the switch lever on the slidewire unit to its center "ZERO" position, and turn the zero adjusting screw on the front of the galvanometer cover so that the step of the galvanometer step table indicated by the small **BLACK** arrow contacts the galvanometer pointer.

I. STANDARDIZE THE BATTERY CURRENT

Push the switch lever to the extreme left "BAL" position with one finger, and turn the knurled disc above it with the thumb until the step of the galvanometer step table indicated by the **BLACK** arrow contacts the pointer. This should be done daily.

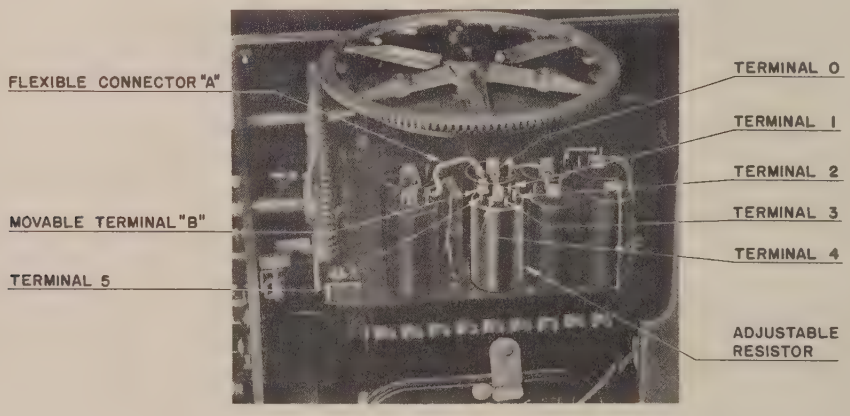


Figure 1360-1
Adjustable Galvanometer Sensitivity Resistor

Reference Drawings
10-G-56
10-G-73

SECTION 1361
Issue 2

CONTROL ADJUSTMENTS AND CORRECTIVE DATA FOR THE BROWN TYPE 113 POTENTIOMETER PYROMETER AND RESISTANCE THERMOMETER

This section covers the control adjustments and corrective data which when followed will make servicing these instruments easier.

A. SETTING THE CONTROL INDEX

B. MERCURY SWITCH CONTROL ADJUSTMENTS

C. CHANGING THE THROTTLING RANGE OF A PROPORTIONING TYPE POTENTIOMETER

D. ADJUSTING THE M-H TYPE RELAY

E. ADJUSTING THE RELATROL RELAY SENSITIVITY

F. M-H PROPORTIONING CONTROL

G. THE BECK CONTROL MECHANISMS

H. THE A.T.C. RELATROL AND BALANCER CONTROL SYSTEMS

I. AIR-O-LINE CONTROL ADJUSTMENTS

J. FULL THROTTLER CONTROL ADJUSTMENTS

K. THE PROGRAM CONTROL SYSTEM ADJUSTMENTS

L. THE AUXILIARY SWITCH

M. THE INTERRUPTER SWITCH

A. SETTING THE CONTROL INDEX

The control index is set by pressing in and turning the small knob immediately above the door knob on the front of the instrument. Turning this knob in a counter-clockwise direction moves the index upscale.

CAUTION: Do not attempt to set the control carriage while the control bar (which is the flat bar behind the scale) is in the DOWN position.

The control setting may be locked by removing the control setting knob. This can be done by releasing the small screw on the control knob shaft bushing, inside the door.

The maximum control setting on a control instrument using mercury switches is 3/4" below the full scale pen position.

The maximum control index setting on an instrument with proportioning control is 1-5/8" below the full scale position. The index cannot be raised above this value due to limitations in the construction of the instrument.

1. Controlling at One Temperature (Single or Multiple Record Instruments)

The control index is set by the knurled knob directly above the door knob as described above.

2. Controlling at Two Different Temperatures (Multiple Record Instruments)

An instrument of this type has two control carriages which may be linked together and set as a unit by turning the control setting knob directly above the door knob, or may be set independently. The right-hand control carriage is always set by means of the control setting knob and the two carriages are connected by a slotted link.

If the indices are to be maintained in fixed relationship to each other, loosen the thumbscrew which locks the control carriages together. This screw is located on the left-hand carriage, in the slot of the connecting link. Slide the left-hand carriage, until the desired distance between the indices is obtained, then tighten the thumbscrew. The setting knob may now be used for setting the indices at the desired point on the scale.

When it is unnecessary to maintain a fixed relationship between the indices the external setting knob may be used to position both indices if the thumbscrew in the connecting link is loosened (but not removed). The lower index should be moved by turning the knob and allowing the right-hand control carriage to pull or push the left-hand carriage to the desired point after which the right-hand carriage may be positioned.

If the desired distance between the indices is greater than the length of the slot in the connecting link, the link must be removed from the instrument and the left-hand control carriage must be set separately by grasping with the fingers and sliding to the proper point.

CAUTION: Do not attempt to move the control carriage to a new position by grasping the control index as the index may become bent so that it will no longer indicate the true control point.

Either control carriage may be fastened at any position on the scale by tightening the corresponding thumbscrew which appears above the scale near the index.

B. MERCURY SWITCH CONTROL ADJUSTMENTS

On 3-position control instruments, see that the adjustable neutral step on the control table has the proper width for the desired operating condition. The width of this neutral may be changed by loosening the two screws in the control table (reached through the two holes in top) and moving the adjustable step to the desired width. This adjustment permits a widening of the neutral step up to approximately 1/2".

If the mercury switch fails to open or close the circuit, inspect the glass tube to see whether it has been broken or cracked. A crack in the glass tube will result in a smoky appearance and the switch should be replaced. On the curved type mercury switch, improper action is sometimes caused by not having the instrument mounted in a level position.

If the switch selections appear to be erratic check the switch assembly. Make sure the switch shaft does not turn and that the individual switches have sufficient friction on the hubs to hold them in whatever position they are placed.

Each mercury switch supporting clip is provided with a friction washer to hold the switch in whatever position it may be pushed by the control fingers. Check the friction on these cup washers and make sure that it is sufficient to hold the switch after it has been tilted by the control mechanism.

C. CHANGING THE THROTTLING RANGE OF A PROPORTIONING TYPE POTENTIOMETER

The Brown Potentiometer has an accessible and easily adjustable method of changing the throttling range. Refer to Dwg.10-G-56. If adjustment is necessary, open the instrument case and swing the frame forward. The stud of the connecting link will be found to be in the extreme outer hole of the movable contact actuating lever. Moving the link to one of the three inner holes increases the angular motion of the movable contact and thus narrows the throttling range.

It is recommended that the link be moved inward, one hole at a time, only after a trial run seems to indicate that the narrower throttling range might be used without causing a cycling of the controlled variable. The effect of changing the throttling range is illustrated in Dwg. 10-G-73.

D. ADJUSTING THE M-H TYPE RELAY

Adjust the pilot relay contact gaps to .010" total, and those for the load relay to .050" total. The gap should be equally divided on either side of the contact blade with no power on the relay.

After the above procedure, connect the relay to the power line, motor, and instrument so that the operation can be tested.

The load relay contact should always snap to approximately its center position without sticking to either side on breaks, should not buzz or arc continuously when making contact on either side, and should not chatter excessively.

If the load relay contacts buzz or chatter excessively, check to make certain that the pilot relay contacts are clean.

If the valve motor hunts, even though the load relay operates correctly as described above, the relay may be too sensitive. This condition may be corrected by unscrewing one or the other of the pilot relay contacts a quarter of a turn at a time until the hunting stops. Usually a one-half turn wider setting of the pilot relay contact gaps will be sufficient to prevent hunting.

E. ADJUSTING THE A.T.C. RELATROL RELAY SENSITIVITY

The degree of accuracy with which a control system will maintain a variable at a given control point depends upon the ability of the system to respond to minor deviations of the variable. This response, in turn, is dependent to a great extent upon the sensitivity of the proportioning relay.

A knob and dial (labeled "Relay Sensitivity"), with arbitrary calibration from zero to 10, are located in the Relatrol Relay and provide a means of adjustment so that the maximum sensitivity, consistent with stable operation, may be attained.

The initial setting of this knob should be at zero on the dial.

After the system has been energized and before the control adjustments are made, the proper relay sensitivity should be determined. Stop the instrument motor in a position to permit free movement of the galvanometer pointer by manually turning the large gear on the right-hand sideplate. Turn the "Relay Sensitivity" knob slowly toward 10 until a rapid cycling condition develops, then return the knob toward zero 1/2 division, or until the cycling stops.

A faint continuous clicking noise from the bridge relay indicates a cycling condition and will be evident when the sensitivity has been increased beyond the critical point. This clicking noise is caused by oscillation of the bridge relay armatures between its two extreme positions.

If the location selected for the Relatrol Relay is subject to considerable extraneous noise, the presence of a cycling condition can be detected by the use of two test lamps. Connect one test lamp between terminals V_2 and 4B, and the other between V_2 and 5B.

The condition of these lamps will indicate now the conditions existing within the control system. When the motor is being operated in the direction to close the valve, the lamp connected between terminals V_2 and 4B will be energized. Conversely when the motor is being operated in the direction to open the valve, the lamp connected between terminals V_2 and 5B will light. When the system is in balance both lamps will be out.

Oversensitivity of the Relatrol Relay is indicated by a rapid alternate flashing of the two lights intermittently, as the bridge relay armature oscillates. Turn the "Relay Sensitivity" knob toward zero until the intermittent flashing of the lights ceases.

Remove the test lamps from the relay terminal plate.

F. M-H PROPORTIONING CONTROL

1. With M-H Relay

In making adjustments to the control system it is important that ample time be allowed for the final effect to be observed and evaluated.

a. Adjustment of Throttling Range

Throttling range is the span through which the controlled variable must pass in order to cause full travel of the motor, and is expressed as a percentage of the total span of the controlling instrument.

As shipped, Brown Potentiometers for use with M-H Proportioning control, are adjusted for a throttling range of approximately 6%.

This setting has been found satisfactory for the majority of applications and should not be changed unless control results indicate the necessity.

If it is desirable to change the throttling range proceed as outlined in part entitled, "Changing the Throttling Range of a Proportioning Type Potentiometer", in this section.

b Setting Angular Rotation of Motor

By means of limit switches, the angular rotation of the crank shaft is adjustable through any part of its 180 degree revolution. The angular rotation should not be decreased more than necessary.

CAUTION: Under no circumstances should the angular rotation be limited to less than 60°. With any shorter travel, the sensitivity of response of the motor is decreased.

To adjust the limit switches remove the section of the motor housing directly opposite the crank shaft, loosen the knurled sleeve, set the limit switch handles to the desired positions, and lock in place by tightening the knurled sleeve.

The limit switches should be set at approximately equal distances from their end positions so that the operating range will be at the center of the resistance element in the motor. This will permit use of the full throttling range for which the controller is set.

2. With Relatrol Relay

a. Energizing the Control System

Place the instrument motor toggle switch in the **ON** position, then close the line switch to the control circuit. Place the toggle switch marked **LINE** in the Relatrol Relay in the **ON** position and place the switch marked **Hand-Auto** in the **Auto** position. The Proportioning Motor will assume a position as determined by the instrument pen or pointer with respect to the control index.

b. Adjusting Throttling Range

As shipped, Brown Potentiometers for use with M-H Proportioning Control, are adjusted for a throttling range of approximately 6%. This setting has been found satisfactory for the majority of applications and should not be changed unless control results indicate the necessity.

The Relatrol Relay has a knob and dial marked "Throttling Range". This knob should be turned to "10" on the dial when the system is placed in operation. If it is found necessary to decrease the throttling range, the knob should be turned toward "0". As the throttling range adjustment is moved from "10" to zero the effective throttling range is reduced 35%. Thus the throttling range may be varied from 6% to 3.9%.

In the event that further reduction of the throttling range is desirable, the Brown Potentiometer has an accessible and easily adjustable method. For further changing the throttling range refer to part entitled, "Changing the Throttling Range of the Proportioning Type Potentiometer", in this section.

By properly combining the two methods, the throttling range may be set at any value between 6% and 1.9%.

The effect of changing the throttling range is illustrated in Dwg. 10-G-73.

c. Adjusting Manual Reset

The knob and dial, marked "Load Compensation", on the Relatrol Relay permits the operator to manually reset the position of the valve with respect to the pen or pointer of the instrument and, thus, to compensate for variations in the operating conditions of the furnace, such as an increased or decreased load.

Set the knob at "0" on the dial. Allow the system to operate a sufficient length of time for the temperature to reach a balanced condition. If the temperature is below the control index, turn the knob toward **OPEN** to increase the valve opening with respect to the pen position. If the temperature is above, turn the knob toward **CLOSE** to decrease the valve opening with respect to the pointer position.

It is recommended that the knob be moved in small steps in order that the effect of the change in valve position in relation to pen position may be observed before making a new adjustment.

d. Setting Angular Rotation of Motor

This set is as outlined under part entitled, "M-H Proportioning Control with M-H Relay", in this section.

e. Operating Manually

To control the valve position manually place the **Hand-Auto** switch in the **Hand** position. Pressing the **OPEN** switch will cause the valve to move toward the fully-open position; pressing the **CLOSE** switch will cause the valve to move toward the fully-closed position.

G. THE BECK CONTROL MECHANISM

1. Adjustments of Beck Single Function Control System with M-H Relay

In making adjustments to the control system it is important that ample time be allowed for the final effect to be observed and evaluated.

a. Adjustment of Throttling Range

As shipped, Brown Potentiometers for use with the Beck Mechanism, are adjusted for a throttling range of approximately 10.5%. This setting has been found satisfactory for the majority of applications and should not be changed unless control results indicate the necessity. To change the throttling range, proceed as outlined in part entitled, "Changing the Throttling Range of the Proportioning Type Potentiometer.

2. Adjustments of the Beck Single Function Control Mechanism with Relatrol Relay

a. Energizing the Control System

Place the instrument motor toggle switch in the **ON** position, then close the line switch to the control circuit. Place the toggle switch marked **LINE** in the Relatrol Relay in the **ON** position and place the switch marked **Hand - Auto** in the **Auto** position. The Beck Mechansim will assume a position as determined by the instrument pen or pointer with respect to the control index.

b. Adjusting the Relay Sensitivity

To adjust the relay sensitivity, proceed as outlined in part entitled, "Adjusting the A.T.C. Relatrol Relay", in this section.

c. Adjusting Throttling Range

As shipped, Brown Potentiometers for use with Beck Single Function Control are adjusted for a throttling range of approximately 10.5%. This setting has been found satisfactory for the majority of applications and should not be changed unless control results indicate the necessity. If an adjustment is necessary, proceed as outlined in the part entitled, "M-H Proportioning Control with Relatrol Relay", in this section.

d. Adjusting Manual Reset

The knob and dial, marked "Load Compensation", on the Relatrol Relay permit the operator to manually reset the position of the valve with respect to the pen or pointer of the instrument and, thus, to compensate for variations in the operating conditions of the furnace, such as an increased or decreased load. If necessary to adjust, see instructions for adjusting manual reset under part entitled, "M-H Proportioning Control with Relatrol Relay", in this section.

e. Manual Operation

To control the valve position manually place the **Hand-Auto** switch in the **Hand** position. Pressing the **OPEN** switch will cause the valve to move toward the fully-open position; pressing the **CLOSE** switch will cause the valve to move toward the fully-closed position.

3. Adjustment of the Beck Triple Function Control Mechanism with M-H or Relatrol Relay

The triple function control mechanism has the following additional control adjustments:

a. Adjusting Proportionate Reset

Adjustment of proportionate reset, referred to as C-2 action in the Beck Triple Function Control System, is made manually by turning the knurled knob at the motor end of the Beck Mechanism.

This reset knob is graduated from zero to 70% and the setting is identified by the graduation which coincides with the white line on the mechanism housing. The % mark is omitted in the graduations.

The recommended initial setting of the knob is 40%.

A comparison of the control record and the curves entitled "Proportionate Reset" on Dwg. 10-G-73 will indicate whether this initial setting must be increased or decreased to produce stable control to a definite temperature.

b. Adjusting Timed Reset

The interrupting contact, which periodically connects the C-3 rheostat across the motor resistor, is located on the right-hand sideplate of the instrument. The operation is factory adjusted to a 2-1/2 second period of contact in a one minute cycle and should not be changed.

The C-3 rheostat is located on the back of the instrument chassis and may be exposed to view by swinging the chassis out of the case.

An initial adjustment of "6" is recommended. Further adjustment is seldom required. However, after the system has been in operation for a time, a comparison of the control record and the curves entitled "Timed Reset" in Dwg. 10-G-73 may indicate that the initial setting should be changed.

c. Effect of Control Adjustments

The effects of control adjustment shown in the sample curves on Dwg. 10-G-73 will vary for different furnaces; principally in regard to the time cycle of the oscillation. Deviations caused by load changes must not be confused with oscillations caused by over-correction of the fuel rates. The deviations caused by load changes are more likely to develop at irregular intervals, while over-correction of the fuel rates will cause more uniform cycles of oscillation.

(1) Throttling range

This has been covered in the part entitled, "Changing the Throttling Range of a Proportioning Potentiometer", in this section.

The effect of changing the throttling range is illustrated in Dwg. 10-G-73.

(2) Proportionate reset

Proportionate reset, or C-2 action, is a permanent displacement of valve position with respect to open position, required to return the controlled variable to or near the control point after a change in load demand. It is a function of the magnitude of the deviation from the control point and is expressed as a percentage of the initial valve displacement resulting from each change in load demand.

The percentage of reset established for the C-2 action is fixed to agree with the constants of the process being controlled. After the initial adjustments have been made, the reset action is entirely automatic, controlling any load within the capacity of the furnace to the set control point.

Refer to Dwg. 10-G-73 for examples of the effect upon the control record of proper and improper settings of the C-2 knob.

(3) Timed reset

Timed reset (C-3 action) is the permanent displacement in valve position, in addition to Proportionate Reset, required to return the controlled variable to the control point after a change in load demand. It is a function of the duration and magnitude of the deviation from the control point and is expressed in arbitrary units from 1 to 10.

Timed reset action is produced by a combination of C-2 action and a shunt, periodically applied, across the motor slidewire.

C-3 shunting action has no effect when the system is in a balanced state with the temperature at the control point. However, when the system is in balance at some point other than the control point and still within the throttling range, the periodic application of the shunt will momentarily unbalance the system and cause the motor to re-position the valve slightly in a direction to force the temperature toward the control point.

This corrective action is dependent upon the value of resistance in the shunt (C-3) circuit, and the amount of deviation from the control point. As the C-3 rheostat is turned from "1" toward "10" the displacement in valve position due to C-3 action increases. Thus the total displacement for a change in load demand is dependent upon the length of time required to return the temperature to the control point.

H. THE A.T.C. RELATROL AND BALANCER CONTROL SYSTEMS

1. Relatrol Control

In making adjustments to the control system, it is important that ample time be allowed for the final effect to be observed and evaluated.

a. Energizing the Control System

Place the instrument motor toggle switch in the **ON** position, then close the line switch to the control circuit. Place the toggle switch marked **LINE** in the Relatrol Relay in the **ON** position and place the switch marked **Hand - Auto** in the **Auto** position. The Valve Operator will assume a position as determined by the instrument pen or pointer with respect to the control index.

b. Adjusting Throttling Range

As shipped, Brown Potentiometers for use with A.T.C. Relatrol Control are adjusted for a throttling range of approximately 10.5%. This setting has been found satisfactory for the majority of applications and should not be changed unless control results indicate the necessity.

(1) **If the A.T.C. Relatrol Relay purchased does not have a knob and dial marked "Throttling Range Adjustment"** proceed as outlined in the part entitled, "Changing the Throttling Range of a Proportioning Type Potentiometer", in this section; only after observation of the control record indicates that a change in throttling range might be desirable.

(2) **When the Relatrol Relay has a knob and dial marked "Throttling Range Adjustment"**, these should be used if it is necessary to alter the effective throttling range of the instrument. If satisfactory control cannot be obtained by means of the throttling adjustment in the relay, proceed as outlined above, to move the connecting link in, one hole at a time, on the movable contact actuating lever of the instrument.

As the "Throttling Range Adjustment" in the Relatrol Relay is moved from zero to "10", the effective throttling range is reduced 40%. Thus, with the connecting link in the outer hole, the throttling range may be varied from 10.5 to 6.3% by turning the Throttling Range Adjustment in the relay from zero to "10". With the connecting link in the second hole, the throttling range may be varied from 9.3 to 5.6%, etc.

c. Adjusting Manual Reset

The A.T.C. Relatrol Relay has a knob and dial, marked "Load Compensation", which permit the operator to manually reset the position of the valve with respect to the pen or pointer of the instrument and, thus, to compensate for variations in the operating conditions of the furnace, such as an increased or decreased load.

Set the knob to "5" on the dial. Allow the system to operate a sufficient length of time for the temperature to reach a balanced condition. If the temperature is below the control index, turn the knob toward **OPEN** to increase the valve opening with respect to the pen position. If the temperature is above, turn the knob toward **CLOSE** to decrease the valve opening with respect to the pen position.

It is recommended that the knob be moved in small steps in order that the effect of the change in valve position in relation to pen position may be observed before making a new adjustment.

d. Operating Manually

To control the valve position manually place the **Hand-Auto** switch in the **Hand** position. Pressing the **OPEN** switch will cause the valve to move toward the fully-open position; pressing the **CLOSE** switch will cause the valve to move toward the fully-closed position.

2. Balancer Control

The A.T.C. Balancer Control System has the following additional control adjustment:

a. Adjusting Rate of Load Compensation

The initial setting of the cam should be such that the "Rate of Load Compensation" contacts are open continuously.

After making any necessary adjustments to the throttling range, as described above, adjust the Rate of Load Compensation cam so that its contact duration will cause the temperature to return to the control point as rapidly as possible without overshooting after any deviation.

Increase the period of closure of contacts to cause the temperature to return to the control point more rapidly.

Decrease the period of contact closure to eliminate hunting or overshooting of the temperature.

b. Effect of Control Adjustments

The effects of control adjustment shown in the sample curves on Dwg. 10-G-73 will vary for different furnaces, principally in regard to the time cycle of the oscillation.

Deviations caused by load changes must not be confused with oscillations caused by overcorrection of the fuel rates. The deviations caused by load changes are more likely to develop at irregular intervals, while overcorrection of the fuel rates will cause more uniform cycles of oscillation.

(1) Throttling range

Throttling range is the span through which the controlled variable must pass in order to cause full travel of the Valve Operator and is expressed as a percentage of the total span of the controlling instrument.

The knob and dial marked "Throttling Range" in the Balancer Relay permit a reduction of approximately 40% in the effective throttling range of the instrument as the knob is turned from zero to "10". Thus the throttling range may be varied from 10.5 to 6.3%.

In addition, the Brown Potentiometer has an accessible and easily adjustable method of changing the throttling range. Refer to Dwg. 10-G-56. Moving the link to one of the three inner holes increases the angular motion of the movable contact and thus narrows the throttling range. Throttling ranges of approximately 10.5, 9.3, 7.4, and 5.5% will be obtained as the link is moved from the outer to the inner hole.

By properly combining the two methods, the throttling range may be set at any value between 10.5% and 3.3%.

The effect of changing the throttling range is illustrated in Dwg. 10-G-73.

(2) Rate of load compensation

Load compensation is the permanent displacement in valve position required to return the controlled variable to the control point after a change in load demand. It is a function of the duration of the deviation from the control point.

Rate of Load Compensation is the rapidity with which the corrective displacement in valve position occurs and is governed by the period of closure of an intermittent contact operated by a rotating and adjustable cam.

The setting of the adjustable cam should be such that the temperature will be forced to return to the control point as rapidly as possible after a deviation due to a change in load demand. However, the process lag is a factor which limits the maximum rate of load compensation and, consequently, the maximum setting of the cam.

A cyclic variation, called hunting, of temperature around the control point occurs when the rate of load compensation is adjusted to too high a value. This condition is due to the inability of the system to respond to the corrective action at the rate it is being introduced, and may be overcome by resetting the cam for a shorter period of contact.

I. AIR-O-LINE CONTROL ADJUSTMENTS

The Brown Air-O-Line is adjusted at the factory to operate with the characteristics as outlined below. If these adjustments have been disturbed they can be corrected by following the procedure specified.

1. Maximum Valve Pressure

With an air supply of 17 lbs. the diaphragm valve pressure should increase to at least 15 lbs. when the flapper is resting firmly on the nozzle and the connection to the air valve is pressure-tight.

a. If the diaphragm valve pressure does not build up properly, first check for leaks in the nozzle system. This includes the unions connecting the nozzle to the pilot valve and the nozzle tube connection at the pilot valve. There may be excessive leakage from the nozzle around the flapper. This can be checked by placing a finger firmly on the nozzle and if the valve pressure builds up to 15 lbs. then the flapper does not cover the nozzle properly. The flapper should then be lined up so it is perpendicular to the nozzle axis when it is against the nozzle.

b. Clogging of the reducer in the pilot valve, (2) in Dwg. 10-G-93 will also prevent the pressure from building up. This can be checked by removing the manual control screw (37) and running a wire through the reducing tube which is 0.008" I.D. and 3/4" long.

c. If the trouble is not found either in the nozzle system or reducing tube, an inspection of the pilot valve exhaust port adjustment should be made. To check this adjustment move the control index or disconnect link (14) so that flapper (5) fully covers nozzle (4). Loosen the lock nut on the exhaust port (7), in Dwg. 10-G-93, and turn the exhaust port in until the valve pressure reaches a maximum and starts to drop again. Then back off 1/2 turn on the exhaust port and lock it in position.

With proper adjustment of the pilot valve, removing the flapper from the nozzle or the reverse action should cause a rapid and uniform change in control valve pressure from 0 to 15 lbs. or vice versa. If it is observed that the pressure changes rapidly at the low and high pressures, but slowly at the intermediate pressures, it indicates that the exhaust port is not located close enough to the supply port.

2. Minimum Valve Pressure

The diaphragm valve pressure should drop to zero when the flapper is removed from the nozzle.

a. If the diaphragm pressure does not drop off, first check the manual control screw (37). This must be seated tightly. If this screw is found to be tight, check for partial clogging of the nozzle or of the exhaust port in the pilot valve.

b. If it is found that the trouble is not due to the above then the pilot valve inlet port adjustment should be checked. The probability is that baffle (6) does not seat properly on the inlet port (1). This is corrected by removing the front cover plate from the pilot valve and then unscrewing the large hexagonal cap.

CAUTION: Do not remove the hexagonal cap with the flapper on the nozzle. Always keep the nozzle uncovered when hexagonal cap is removed.

The small nut on the end of the pilot valve shaft, which also acts as a baffle for the exhaust port, should be unscrewed and the disc which covers the inlet port (1) should be turned in so that with the flapper away from the nozzle, the disc just covers the supply port. By listening closely the point at which the inlet port is covered can be recognized. Precaution should be taken to avoid screwing the disc in too far as this will cause distortion of the disc and it will not cover the supply port properly. After the disc has been adjusted it should be locked in place with the exhaust baffle nut.

CAUTION: When replacing hexagonal cap on pilot valve always back off on the exhaust port (7) so that it will not press against the baffle when the cap is seated.

After the hexagonal cap is replaced the exhaust port (7) should be adjusted as described in part 1. "Maximum Valve Pressure", under c.

3. Throttling Range Adjustments

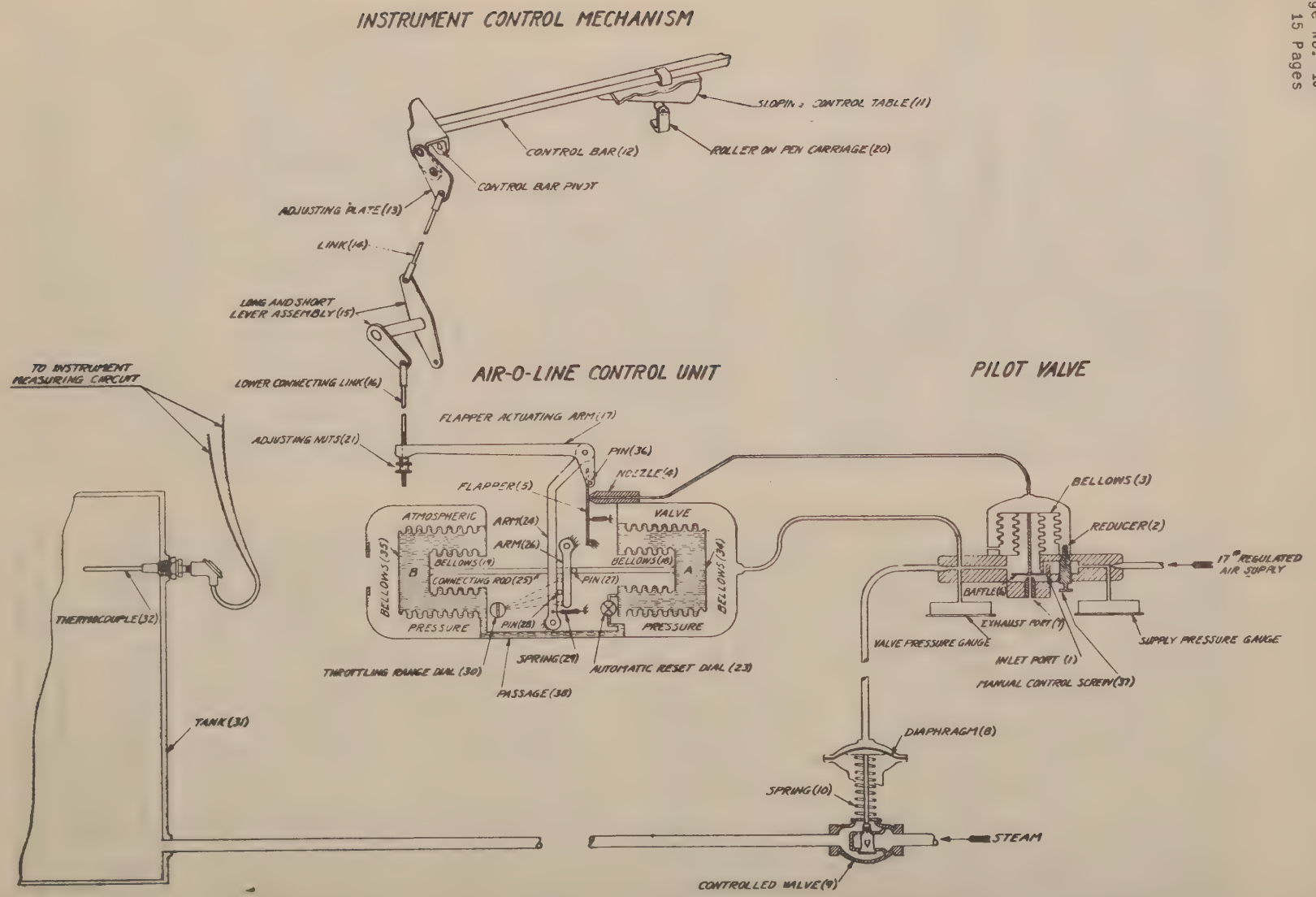
With the instrument pen at the control point, changing the throttling range dial should not change the diaphragm valve pressure appreciably.

To check this action, set the control index at the real control point (this may not necessarily be at the instrument pen or pointer if the instrument adjustments have been disturbed). To find the real control point follow procedure given in 4 (a) below, but do not adjust the control point at this time. Simply find where it is and leave the index there.

With the index at the control point, observe relation between arm (26) and arm (24). These two arms should be parallel so the diaphragm valve pressure does not change when the throttling range is changed. If they are not parallel, adjust eccentric pin (27) to make them so. Whenever eccentric pin (27) is adjusted, the control point is shifted and therefore the control index must also be changed to the new control point. By adjusting eccentric pin and resetting control index alternately, the two arms (26) and (24) can be made parallel to each other when the index is at the control point. To check this adjustment operate the throttling range dial from 10% to 100% with the control index at the control point. The diaphragm valve pressure should change not more than approximately 1/4 lb. if this adjustment is made properly.

4. Adjusting Control Point

The instrument pen or pointer should coincide with the control index when the index is at the control point.



Drawing 10-G-93

Schematic Drawing - Potentiometer Air-O-Line Controller

a. To check for control point, set the control point index to agree with the pen or pointer. Move automatic reset dial to #1 position and observe diaphragm valve pressure. If this pressure changes over a period of several minutes, then the real control point is not that indicated by the index. This check can be made more accurately with a narrow throttling range such as 10%. The real control point is the index setting at which the pressure remains steady.

b. To adjust the index to agree with the control point, set the index to coincide with the pen or pointer and set automatic reset dial to #1 position. If the diaphragm valve pressure is observed to be falling, adjust nozzle towards the flapper; if the pressure is rising, adjust nozzle away from the flapper.

With the correct nozzle adjustment there will be no change in diaphragm valve pressure with the index coinciding with the pen or pointer and the automatic reset dial at #1.

J. FULL THROTTLOR CONTROL ADJUSTMENTS

The Brown Full Throttlor is adjusted at the factory to operate with the characteristics as outlined below. If these adjustments have been disturbed they can be corrected by following the procedure specified:

1. Maximum Valve Pressure

With an air supply of 17 lbs. the diaphragm valve pressure should increase to at least 15 lbs. when the flapper is resting firmly on the nozzle and the connection of the air valve is pressure tight. If the diaphragm valve pressure does not build up properly, proceed as outlined under part entitled, "Air-O-Line Control Adjustments", in this section.

2. Minimum Valve Pressure

The diaphragm valve pressure should drop to zero when the flapper is removed from the nozzle. If the diaphragm pressure does not drop off, proceed as outlined under part entitled, "Air-O-Line Control Adjustments", in this section.

3. Nozzle Adjustment

With the control index coinciding with the instrument pen or pointer and the manual reset screw in approximately its middle position, the diaphragm valve pressure should be between 5 and 10 lbs. This pressure also should not vary more than about a pound when the throttling range dial is adjusted from 10% to 100%.

If the diaphragm valve pressure does not act in this manner, it indicates that the nozzle is out of adjustment. The nozzle can be adjusted by following the procedure outlined as follows:

a. Set throttling range dial at 10 and observe valve pressure. If it is above 10 lbs., adjust nozzle away from flapper; if it is below 5 lbs., adjust nozzle towards flapper.

b. Move throttling range dial to 100 and repeat adjustments outlined in (a).

c. Repeat these adjustments alternately at 10 and 100 on throttling range dial, until the pressure is within the 5 to 10 lb. range and does not change more than one pound when the throttling range dial is moved from 10 to 100.

4. Throttling Range

If the record appears to drift without any definite signs of being controlled, the throttling range dial should be moved to a smaller number. If on the other hand a periodic cycle is produced on the record, then the throttling range should be widened by moving the throttling range dial to a larger number. With proper adjustment on the throttling range dial the record will just be beyond the point of cycling.

5. Manual Reset

After the proper throttling range has been found, the control index can be made to coincide with the real control point (the point at which the instrument record is maintained), by shifting the manual reset screw. This is done by first observing the pressure on the diaphragm valve gauge (left-hand gauge), and then moving the index to agree with the instrument reading. Then adjust the manual reset screw so that pressure on the diaphragm valve gauge returns to the value observed before moving the index.

6. Manual Control

The manual control screw (37) is for use only in emergencies when it is desired to by-pass the control instrument.

Before operating this screw, first move the control index as far as possible in the direction which will drop the diaphragm valve pressure. Then turn the manual control screw in a counterclockwise direction slowly until the desired diaphragm valve pressure is reached. These two operations should be done simultaneously where a temporary drop in valve pressure is not desirable.

To return to automatic control turn the manual control screw clockwise until it is seated tightly.

CAUTION: The manual control screw must be seated tightly in clockwise direction for proper automatic operation of the instrument.

7. Corrective Data

When a full throttlor is properly adjusted for automatic control of a process, no further adjustments should be necessary. If the instrument begins to control poorly, after having been previously adjusted properly, do not tamper with the adjustments until external factors, more likely to cause trouble, have been investigated. Checks should be made of the diaphragm valve operation or for leaks in the lines connecting the instrument to diaphragm valve, air filter, and pressure regulator, any of which may contribute to poor control.

A maintenance of a clean and dry air supply to the instrument is absolutely necessary for continuous satisfactory operation. Although the instrument contains a secondary filter it is up to the primary filter to clean the air and remove liquids. Where liquids (oil and water) are excessive, the petcock at the bottom of the filter should be left partially open in order to provide a continuous drain. The filtering material in the filter should be replaced periodically, the frequency depending on local conditions.

If the diaphragm valve pressure does not build up properly and there are no leaks in the air lines, the reducer may be clogged. The reducer is a part of the manual control screw and can be removed from the pilot valve by unscrewing the manual control screw, counter-clockwise, see drawing 10-G-93 in the part entitled, "Air-O-Line Control Adjustments", in this section.

Clean out the small hole in the manual control screw by using a fine wire (0.008" diameter or less). The pen cleaners, supplied in the accessories with the instrument, can be used.

If the reducer is clogged and it is not practical to take the instrument off control for cleaning the reducer, the manual control can be adjusted to a point where the automatic control will continue to function. Turn the manual control in a counter-clockwise direction until proper automatic control is again obtained. The manual control screw need be turned only a small amount to accomplish this.

CAUTION: Do not turn the manual control screw too far in counter-clockwise direction as this will prevent the diaphragm valve pressure from dropping properly when the nozzle is uncovered.

For checking this adjustment move the control index in the direction to drop the diaphragm valve pressure and see if this pressure drops as it should.

K. THE PROGRAM CONTROL SYSTEM ADJUSTMENTS

For the purpose of explanation the program control system may be divided into two parts: the temperature control system, and the program control system.

1. Temperature Control

The temperature of the furnace is controlled at the point indicated by the position of the control index on the chart or scale, even though the control index may move up or down the scale.

This control may be effected through electrical means or through pneumatic means depending upon which has been selected as best for the particular application.

For further details of the temperature control system, please refer to the accompanying instructions for that type of control.

2. Adjusting the Equipment

The equipment which must be adjusted or set, before operating the program, is indicated on the external wiring diagram which accompanies these instructions. The various equipment may be set as follows:

The heating rate or cooling rate should first be set on the rate controllers. If the dials of the rate controllers are not calibrated directly in degrees per hour, the rates may easily be computed as follows:

If R = desired heating or cooling rate in degrees per hour
S = speed of control point drive in inches per hour
C = range of instrument chart or scale (0-1000 = 1000 degrees but 1000-3000 = 2000 degrees)
P = percentage of contact closure

then,

$$P = \frac{11 \times R}{C \times S} \times 100$$

If the contact closure of the rate controller is 0-100%, the dial may be set directly to the value P. If the contact closure of the rate controller used is 0-40%, the dial must be set to a value which is two and one-half times the value P.

It is suggested that the above equation be worked out completely for every 2% setting and a card made up listing the percentage settings opposite the result and heating or cooling rate. The card may be mounted near the rate controller for ready reference.

It is important to note that the **rate controllers should never be set below 10%** because below this setting there is a possibility that the accuracy will decrease.

Each soaking time controller should be set for the desired holding or "soaking" period. This may be done by simply turning the knob of the dial to the desired number of hours.

Further information for setting the soaking time controllers or rate controllers is contained in the instructions for those units.

The auxiliary switches must be set to determine the holding temperature or other points in the program. See the part entitled, "Setting the Auxiliary Switch", in this section.

The program control system should now be completely adjusted to provide the desired program sequence.

3. Starting the Program

Before starting the program, the points listed on the external wiring diagram for the control system should be checked carefully to determine if all of the auxiliary equipment is properly adjusted.

The control index should now be set to the desired starting temperature for the program.

Then if the control equipment, such as relays, motors, valves, etc. are properly connected, the line switch to the program control system may be thrown.

If all connections seem to be in proper order, the **RESET** button may be pushed. The program sequence will then follow.

Upon starting for the first time, it is well to run the program completely through without the control motors or valves operating and with the furnace unloaded. The operation of the program control system may then be closely checked by observation.

During the holding or "soaking" period when the control index is stationary at some point, the temperature control system may be turned on with the furnace unloaded to determine whether the control valves, etc. are properly adjusted.

4. Altering the Program Sequence

If it is desired to alter the entire arrangement of the program sequence - for instance, provide two or three holding periods in place of one, or provide two rates of rise where there is now one rate, - the nearest office of the Brown Instrument Company should be contacted.

The Brown Instrument Company will be pleased to detail the changes necessary in the system to provide additional functions.

L. SETTING THE AUXILIARY SWITCH

An auxiliary switch is supplied when ordered with the instrument. Dwg. 10-G-92 illustrates an auxiliary switch SPST, mounted on the left-hand sideplate and operating from the pen carriage spiral shaft. The switch is tilted when two slotted discs, driven by gears from the pen or control spiral shaft, come in alignment.

Referring again to Dwg. 10-G-92, the auxiliary switch may be adjusted to operate at any desired point on the scale as follows:

1. Turn the slotted hub (A) with a screwdriver until the three (3) red marks, M_1, M_2, and M_3 are in alignment. The proper direction to turn is determined by observing the marks M_1 and M_2. If they are spreading instead of closing in, reverse the direction and keep turning until all of the marks come together. Several turns may be necessary.

   When all red marks are in alignment it will be observed that the slotted discs are also in position to allow the switch to tilt if the spiral shaft (S) is turned.

2. Hold the large upper gear (G) with the fingers of the left hand and turn the slotted hub (A) with a screwdriver against friction. As (A) is turned, the pen or control carriage moves up or down scale. Turn it until the index below the scale indicates the exact setting at which the auxiliary switch is to operate.

   The auxiliary switch is now completely adjusted. Whenever it is desired to make a change in the setting, simply repeat operations (1) and (2) above.

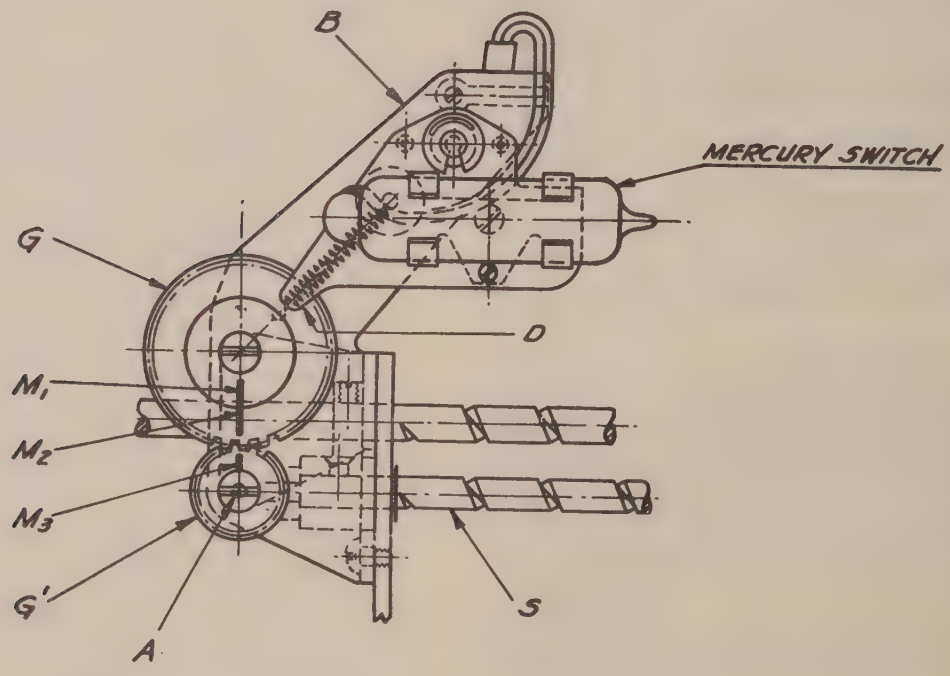
The auxiliary switch mechanism is very sensitive to small movements of the pen or index. A movement of about 1/32" on the scale is sufficient to operate the switch. It can, therefore, be set with precision and will retain the setting.

M. THE INTERRUPTER SWITCH

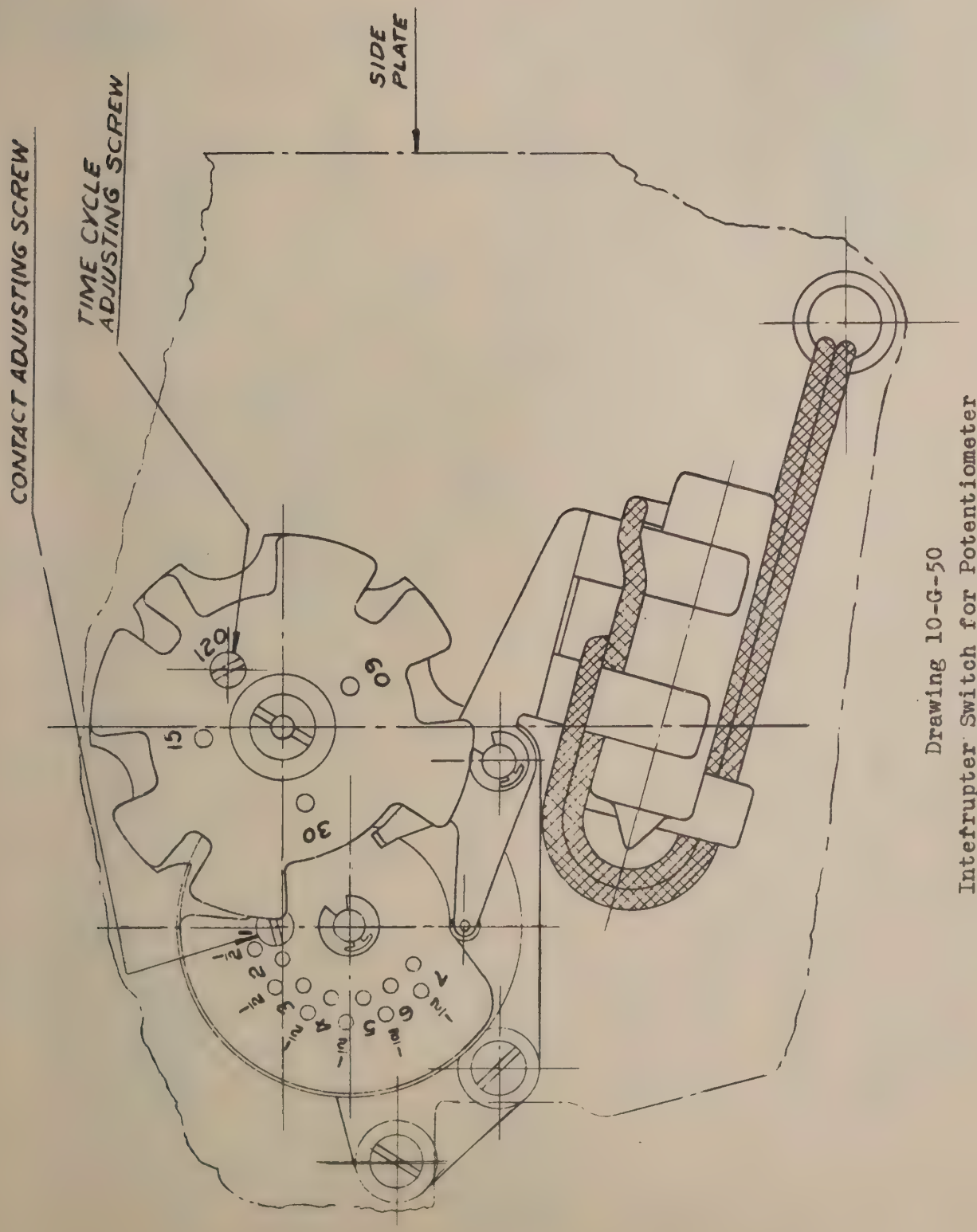
Referring to Dwg. 10-G-50, the contact period may be adjusted as follows:

The duration of contact is changed by removing the screw in the left-hand disc and placing it in the hole opposite the time of contact duration desired.

The time cycle during which one contact is made and broken is changed by removing the screw in the right-hand disc and placing it in the hole opposite the time cycle desired.

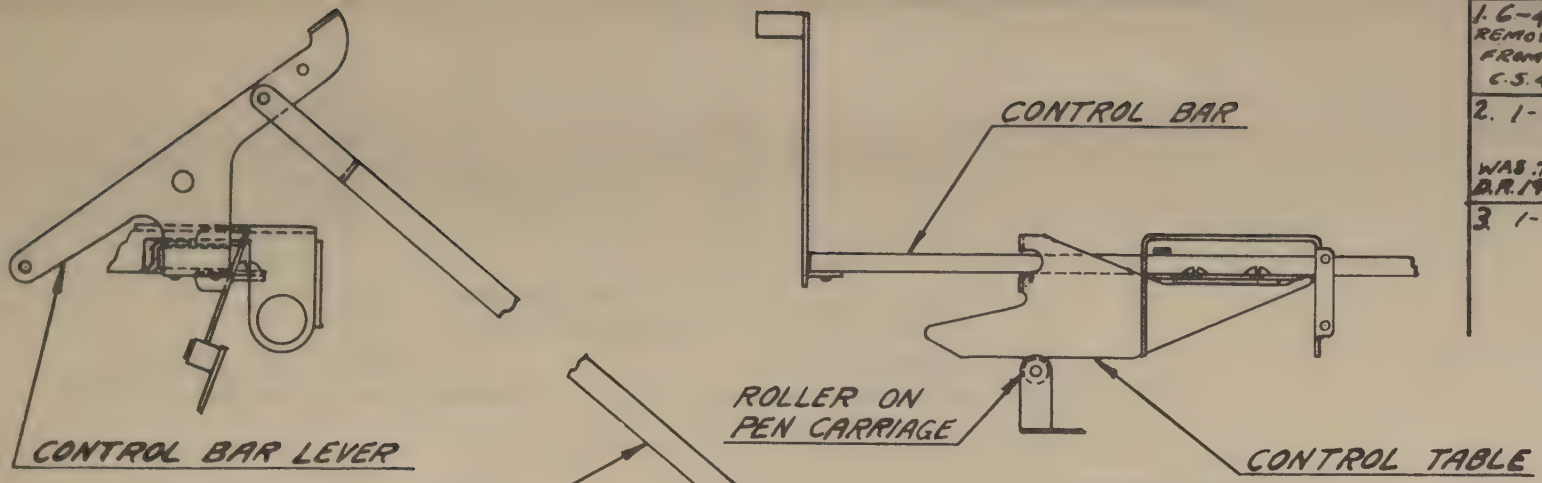


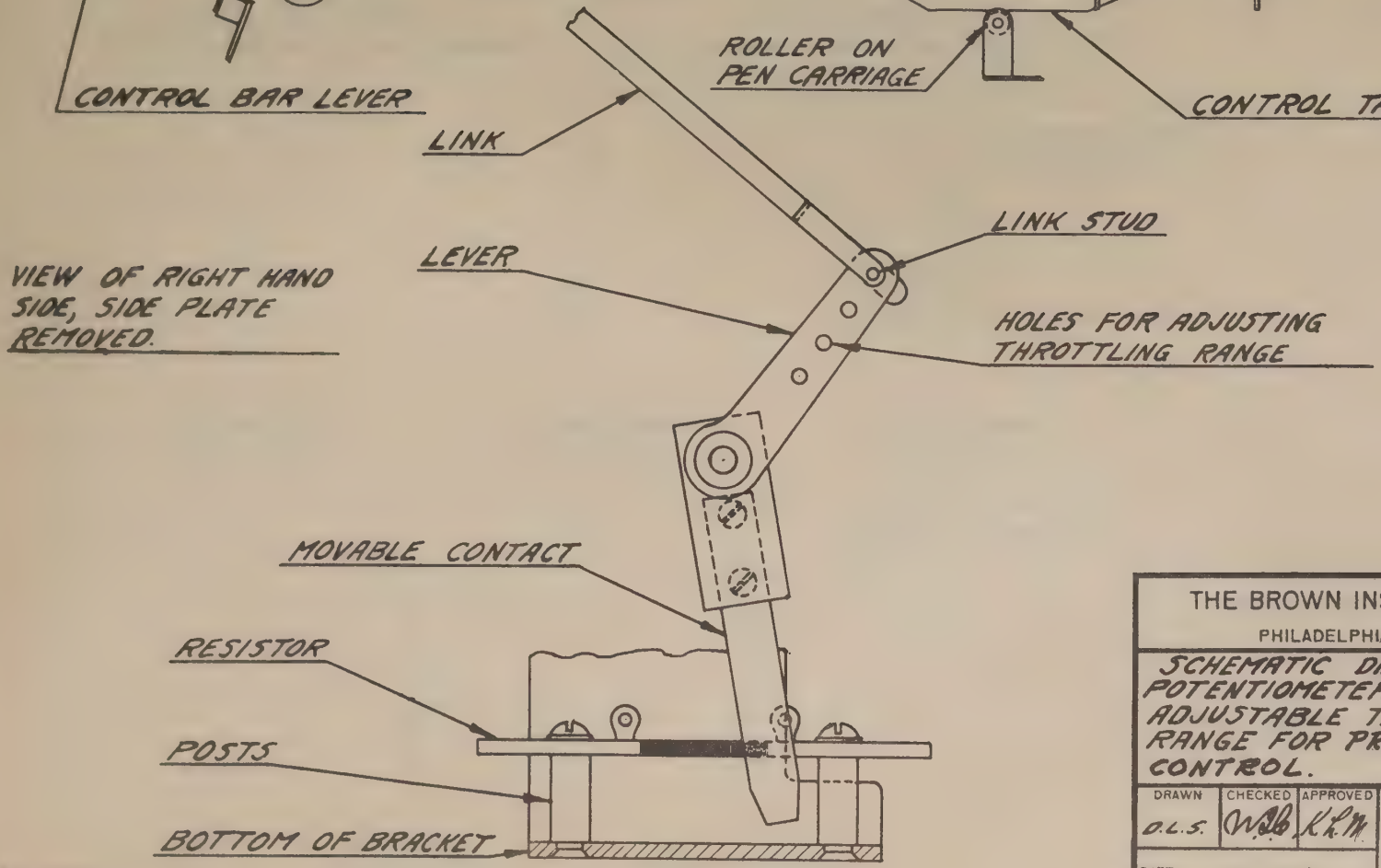
Drawing 10-G-92
Auxiliary Switch for Potentiometer



Drawing 10-G-50
Interrupter Switch for Potentiometer

1. 6-4-35 REMOVED M.N. FROM TITLE C.S. 4714	K.L.M.
2. 1-6-43 WAS 7-A-47 D.R. 192-1	E.T.
3 1-2-47	E.T.





VIEW OF RIGHT HAND SIDE, SIDE PLATE REMOVED.

THE BROWN INSTRUMENT CO.
PHILADELPHIA, PA, U.S.A.

SCHEMATIC DIAGRAM OF POTENTIOMETER WITH ADJUSTABLE THROTTLING RANGE FOR PROPORTIONING CONTROL.

DRAWN	CHECKED	APPROVED	DRAWING NO
O.L.S.	W.S.B.	K.L.M.	10-G-56
DATE 6-4-35			

F 474-10-32

1.	6-11-40	E.F.
WAS 67-S-51 D.R. 217-1		
2.	12-26-46	E.F.

TEMP OSCILLATES
THROTTLING RANGE TOO NARROW

TEMP. DRIFTS
THROTTLING RANGE TOO WIDE

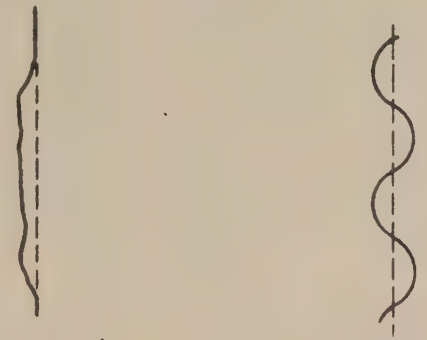
PROPORTIONATE RESET

C2 SETTING TOO LOW

C2 SETTING CORRECT

C2 SETTING TOO HIGH

TIMED RESET



C3 SETTING TOO LOW

C3 SETTING TOO HIGH

N.F.

THE BROWN INSTRUMENT CO.
PHILADELPHIA, PA, U.S.A.

EFFECT OF CONTROL ADJUSTMENTS OF POTENTIOMETER & BECK MECHANISM

F.A.	✓	E.F.	DRAWING NO. 10-G-73
DATE 6-7-40			

SECTION 1362
Issue 2

MAINTENANCE OF THE BROWN TYPE 113 MECHANICAL POTENTIOMETER AND RESISTANCE THERMOMETER

A. Cleaning the Print Wheel
B. Cleaning the Thermocouple Switches
C. Cleaning the Slidewire
D. Chart Replacement
E. Standardizing
F. Checking Mechanical Zero
G. Maintenance of Dry Cells
H. Maintenance of Standard Cells
I. Servicing the Motor
J. Maintenance of the Control Mechanisms

A. CLEANING THE PRINT WHEEL

Clean the numeral print wheel assembly each time the ink pads are replaced, or more frequently if necessary. Use a small, clean, dry brush with stiff bristles, such as a typewriter or tooth brush. Rotate the print wheel by means of the printing cam and ratchet assembly on the chart drum shaft at the right-hand side plate.

B. CLEANING THE THERMOCOUPLE SWITCHES

Clean the multiple switch contacts when renewing the chart and ribbon or ink pads.

CAUTION: Do not use abrasives on the switch contacts.

Unclip the base of the switch and lower it sufficiently to allow the oil to drain from the switch brushes. Then remove it entirely and empty the oil.

Clean the contacts and brushes with a brush and benzol or naphtha. Dry them with a lint-free rag. Take care not to bend the brushes.

Refill with immersion oil to cover the face of the contacts approximately 1/16 inch.

Replace the switch base.

C. CLEANING THE SLIDEWIRE

To obtain satisfactory operation, it is important to clean the slidewire approximately twice a year. Carefully follow these instructions when replacing old slidewire oil with new oil. Obtain slidewire immersion oil from the Brown Instruments Division. Do not use substitutes. All traces of the old oil must be removed from the slidewire before adding new oil. This cleaning operation is not necessary on new slidewires that are being put into operation for the first time, since it has been done at the factory before shipment.

1. Run the print hammer upscale against the stop. Carefully note the relative positions of the arrows on the two large bevel gears, located one above and one at the side of the slidewire. Maintenance of the correct relationship is important in obtaining the proper synchronism between the slidewire contactor position and the print hammer position. Normally, the arrow on the horizontal gear is displaced approximately one-half tooth toward the rear of the chassis from the arrow on the vertical gear.

2. Remove the slidewire assembly from the instrument by loosening the nine small screws on the back of the unit, removing the two large screws that clamp the unit to the metal frame, and lifting out the assembly.

   DO NOT loosen any of the set screws used to fasten the bevel gears to their respective shafts, as this will throw the instrument out of mechanical adjustment.

3. Remove the two screws holding the standardizing switch cover to the slidewire and remove the cover. Wipe the contacts, brush, brush holder, and contact point of the load spring with a soft, lintless cloth saturated with alcohol or carbon tetrachloride. Then coat these points with a small amount of Brown Instruments Division lubricant type L-9. Replace the standardizing switch cover.

4. Remove the wire bail holding the glass jar to the slidewire unit, then lift the slidewire out of the jar. Hold the glass jar in an upright position to avoid spilling the oil.

5. Throw the oil away.

6. Rinse the slidewire unit and glass jar in commercial grade benzol or naphtha.

   CAUTION: Benzol or naphtha should be used only where there is a good circulation of air to carry off the fumes, because these solvents are explosive, inflammable, and toxic.

7. Form a small piece of fine sand paper (No. 0000), into a roll of the same diameter as the contact roller. (Do not use emery or crocus.) Rub this lightly along the entire length of the slidewire and battery rheostat, touching all surfaces where the contact roller normally travels. Sand just enough to remove the film on the wire so that all turns are clean and bright. Do not actually remove metal as that would change the calibration.

8. Scrub the slidewire thoroughly with benzol or naphtha, using a small stiff brush. Brush in such a way that the bristles will remove all foreign particles between the turns of wire.

9. Rinse the unit with clear benzol or naphtha. Do not use dirty benzol or naphtha for this last rinse. Shake off excess cleaning liquid and allow the unit to air dry for at least fifteen minutes.

10. Replace the slidewire inside the jar; then hook the bail to the moulding and lock it. Be sure that the locking lever on the bail is pointed toward the front of the instrument when the slidewire assembly is replaced.

11. Before replacing the slidewire assembly in the instrument, turn the bevel gear moving the contactor from one end of the slide to the other. If the contactor jams at any point, shift the glass jar with respect to the slidewire until the contactor is free over the full length of its travel.

12. Run the print hammer up scale against the stop. Turn the slidewire bevel gear in a clockwise direction until the contactor is at the top end of the slidewire.

13. Then place the slidewire assembly in the frame, making sure that the arrows on the bevel gears are lined up as they were when the assembly was removed. Tighten the two screws holding the slidewire assembly to the frame and the 9 small screws on the back of the unit.

14. Fill the slidewire jar with new immersion oil to the oil level line. Replace the screw plug.

D. CHART REPLACEMENT ON RECORDERS

Renew the chart as required. The word RENEW is stamped on the chart every 6 inches with the first mark appearing 96 inches before the chart runs out. At a chart speed of 2 inches per hour, the chart will last for 48 hours from the time the first mark appears.

To remove the chart, push the bottom leaf spring on the right-hand side plate away from the side plate just far enough to release the re-rolled chart. When installing a new chart, push the top leaf spring on the right-hand side plate away from the side plate enough to release the metal tube, then slide off the cardboard tube left from the old chart. Slide the metal tube through new chart, letting the tube extrude about 1 inch on the left side. Place the extruded end of the tube on the chart disc in the left-hand side plate. Next slide the chart all the way over the tube and push the top leaf spring away from the side plate until the right end of the metal tube can be slipped in place: then release the spring.

Lead the paper up and over the driving drum from the back, and thread it between the tear-off glass and the writing platen, making sure that the pins in the chart drum are engaging the chart paper. The chart paper can then be fed forward by turning the large knob on the chart drum shaft.

Place the cardboard tube left over from the previous chart between the chart reroll discs by pushing the bottom leaf spring away from the side plate until the tube can be slipped into position. Then fasten the starting end of the new chart to the cardboard tube by means of the sticker found on the new chart. Be sure, before fastening the chart, that the pull on it is evenly divided across its width.

When ordering new charts, always specify the chart number which is marked on the margin.

E. STANDARDIZING

Restandardize the pyrometer battery current once a day.

Push the switch lever to the extreme left "Bal." position with one finger, and turn the knurled disc above it with the thumb until the step of the galvanometer step table indicated by the BLACK arrow contacts the pointer.

The current from a new battery drops off rapidly for the first day or two. During this period the instrument should be standardized several times a day, after which it will be necessary only once a day. Replace batteries when the standardizing rheostat has reached the end of its travel and the instrument can no longer be standardized.

Resistance thermometers do not require standardizing.

F. CHECKING MECHANICAL ZERO

Check the mechanical zero once a week.

While the motor is running, push the switch lever on the slidewire unit to its center ZERO position, and turn the zero adjusting screw on the front of the galvanometer cover so that the step of the galvanometer step table indicated by the small BLACK arrow contacts the galvanometer pointer.

G. MAINTENANCE OF DRY CELLS

In resistance thermometer instruments, replace the dry cells every four months.

In Brown Potentiometers, replace the cells when the instrument can no longer be standardized.

When temperatures below 32°F or above 140°F are encountered, remove the dry cell to a location where the temperature is moderate (approximately 75°F) and run the necessary wires to the battery terminals inside the instrument.

The proper number of cells to be used for a given instrument is covered in the tables in the Section entitled, "Description and Data on Component Parts of Type 113 Mechanical Potentiometer".

H. MAINTENANCE OF STANDARD CELLS

When temperatures below 32°F or above 140°F are likely to be encountered, remove the standard cell from the instrument and place it in a location where the temperature is moderate (approximately 75°F). Use copper wire of No. 18 gauge or larger, and observe the polarity marks. These wires can follow the measuring circuit cable across the frame to the hinges on the side of the case, then out through a conduit. Fasten the wires to the standard cell leads by means of the terminal screws in the tapped terminal clip. Tape the connections to avoid short circuiting.

CAUTION: Take care to prevent breakage when removing the cell and in placing it in the new location. Place it with the terminals at the bottom and do not set the cell on any metal, as the terminals will be shorted.

I. SERVICING THE MOTOR

Potentiometer motors should be inspected, cleaned, and relubricated after one year of service.

When disassembling the motor, note the positions of all shims, washers, and other parts. They must be replaced in their former positions when the motor is being assembled in order to line up the rotor and bearings. Failure to observe this may cause binding and noise, and may result in premature failure of the motor.

The motor used will be either an Emerson or a Robbins and Myers. For either, proceed as follows:

1. Remove both end bells from the motor frame by removing three screws from the gear case side and four screws from the opposite side. Then withdraw the armature from the housing.

2. Do not attempt to remove the rotor bearings.

   The Robbins and Myers rotor bearings are hermetically sealed and cannot be relubricated. On an Emerson rotor, wash the bearings with gasoline and inspect them for excessive wear. Repack each bearing with one-half level teaspoonful of special grease which can be obtained from the Brown Instruments Division.

3. Remove from the gear case both the gear case cover and the vertical gear shaft cover adjacent to it.

4. Remove as much grease as possible from the gear case with a small flat piece of wood. Wash out the case and vertical shaft bearing

thoroughly with gasoline. Do not use kerosene as it may collect in pockets and dilute the new grease.

5. Inspect gears and bearings for excessive wear.

6. For new grease, use a sodium base non-tracking grease obtainable from the Brown Instruments Division. Vigorously churn it with a spoon or a small wooden paddle, until it becomes stringy. Then fill the gear case to the top of the output shaft bearing. Apply a small amount of grease to the vertical shaft ball bearing and force it into the spaces in the race.

7. Clean the housing, rotor, and end bells of all dirt and grease. Do not disturb the capacitor connections except in replacing capacitors. Insert the rotor into the motor housing and fasten the two end bells in place.

8. Check for end play. There should be approximately .010 inch end play in the rotor after the motor has been assembled. Should the end play exceed .020 inch, it is an indication that shims have been omitted in reassembling the motor or that wear has taken place: insert additional shims to reduce the end play to approximately .010". Check for excessive wear on the output shaft. Apply a few drops of light machine oil to the bearing oil cup.

9. Shellac a new gasket to the top of the gear case. Also fasten the vertical shaft cover in place.

J. MAINTENANCE OF THE CONTROL MECHANISMS

The automatic control mechanisms require very little maintenance. A little experience is necessary to determine the frequency of inspection. The establishment of a periodic schedule of inspection is recommended.

1. Mercury Switch Control System

If the mercury switch fails to open or close the circuit, inspect the glass tube to see whether it has been broken or cracked. A crack in the glass tube will result in a smoky appearance and the switch should be replaced. On the curved type mercury switch, improper action is sometimes caused by not having the instrument mounted in a level position.

If the switch selections appear to be erratic, check the switch assembly. Make sure that the switch shaft does not turn and that the individual switches have sufficient friction on the hubs to hold them in whatever position they are placed.

Each mercury switch supporting clip is provided with a friction washer to hold the switch in whatever position it may be pushed by the control

fingers. Check the friction on these cup washers and make sure that it is sufficient to hold the switch after it has been tilted by the control mechanism.

2. M-H Proportioning Control System

a. Cleaning the Contact and the Resistance Element

(1) In the Instrument

The resistance element and the contact are located on the rear of the chassis at the lower right-hand side and are exposed to view by swinging the chassis out of the case.

Keep the movable contact and the working portion of the resistance element clean at all times. The materials are corrosion-resistant and, if kept clean, will function with reliability. A periodic inspection at monthly intervals is recommended.

The pressure between the contact and the resistance element in the controller should be checked occasionally. If the contact pressure is too low, electrical continuity will not be maintained; if it is too high, excessive wear will result.

The contact pressure should be between 1 1/2 and 2 ounces. If it is outside those limits, adjust it by swinging the contact arm completely off the resistance element assembly and then bending the contact arm to increase or decrease the pressure as required.

(2) In the Proportioning Motor

The resistor and contactor in the proportioning motor should need no attention for the life of the motor.

b. Lubrication

The gear unit of the proportioning motor is packed in grease and should require no attention during the normal life of the motor.

Oil the motor bearings once each year. Use a good grade light oil and apply a few drops to the two oil holes in the motor housing.

NOTE: Never use a heavy commercial grade of oil on the proportioning motor. Use a light, good quality instrument oil.

3. M-H Proportioning Relay

This section covers the maintenance of the M-H proportioning relay. The procedure outlined in the following paragraphs should be followed

whenever the relay fails to operate satisfactorily as a result of sticking or continuous arcing of the relay contacts.

NOTE: In the following paragraphs, reference is made to the pilot relay and the load relay, both of which are parts of the proportioning relay. The two relays can be identified by looking for the cross-shaped phosphor-bronze damping spring which is mounted on the armature of the load relay only.

a. Cleaning Relay Contacts

Clean the relay contacts by rubbing a strip of clean, rough, unglazed paper back and forth between the contacts of each set while holding the armature down on the proper side. Do not use abrasive paper or cloth unless the contacts are extremely dirty. If such paper is used, select only the finest grade and use it carefully. VIOLENT RUBBING IS UNNECESSARY.

If the load relay contacts are badly burned it may be necessary to use a small, fine file to clean them. Always use fine grade abrasive cloth or paper after filing. It should never be necessary to use a file on the pilot relay contacts.

After using abrasive paper always clean the contacts with rough paper or cloth to remove all grit and loose metal particles.

b. Adjustment of Relay Contacts

Adjust the pilot relay contact gaps to .010 inch total, and the contact gaps for the load relay to .050 inch total. With no power on the relay the gap should be equally divided on either side of the contact blade. Bend the blade to make the spacing correct.

c. Test Operation

After the above procedure, the relay should be ready for operation. Connect the relay to the power line, motor, and instrument so that the operation can be tested.

The load relay contact should always snap to approximately its center position without sticking to either side on breaks, should not buzz or arc continuously when making contact on either side, and should not chatter excessively.

If the load relay contacts buzz or chatter excessively, check to make certain that the pilot relay contacts are clean.

If the valve motor hunts, even though the load relay operates correctly as described above, the relay may be too sensitive. This condition may be corrected by unscrewing one or the other of the pilot relay contacts a quarter of a turn at a time until the hunting stops. Usually a one-half turn wider setting of the pilot relay contact gaps will be sufficient to prevent hunting.

4. A.T.C. Relatrol Relay of the Electronic Type

a. The Electron Tubes

These are standard radio tubes which are operated considerably below their nominal ratings in order to insure trouble-free performance.

Replacement tubes may be purchased from any local radio parts dealer.

It is recommended that the tubes be replaced every six months.

NOTE: For most satisfactory performance replace both tubes at the same time.

After replacing tubes, recheck the relay sensitivity, as described in the part, "Adjusting the Relatrol Relay Sensitivity", in the section entitled, "Control Adjustments and Corrective Data".

The Bridge Relay is a part of the Relatrol Relay. It is an easily removable unit which is plugged into a socket at the top of the Relatrol Relay chassis. The contacts are enclosed and normally do not require any attention.

Should the system fail to operate because of failure of the bridge relay to operate properly, it is recommended that the bridge relay be replaced by a new unit and that the old unit be returned to the manufacturer for repairs.

5. Air Control Systems

A clean and dry air supply to the system should be maintained. Where liquids (oil and water) in the air supply are excessive, partially open the petcock at the bottom of the filter in order to provide a continuous drain. Replace the filtering material in the filter periodically, the frequency depending on local conditions.

All controlled valves used with the air operated controller must be equipped with stem lubricator. The lubricant used should apply to the particular fluid being controlled and should be inserted before putting valve into service. Never tighten the stuffing box to stop leakage; insert more lubricant instead.

6. The Beck Mechanism

The resistor and contactor in the Beck Mechanism need no attention for the life of the motor.

a. Lubrication

(1) Beck Mechanism

The inside of this unit is greased to permit approximately five years of service without attention. The motor is equipped with grease-sealed ball bearings, and since the motor's speed is only 75 rpm, the bearings should last for the life of the unit without attention. Twice a year inspect the control mechanism under the deep cover where the slidewire and limit switches are located and place a few drops of oil on the ratchet and pawls.

CAUTION: Do not allow oil to get on the slidewire.

(2) Control Valve

If the control valve is provided with a means of lubrication, lubricate it. If the fuel is gas which contains coal tar, ordinary lard is a very effective lubricant and a great aid in cleaning a valve that may have become plugged with tar deposits.

Accumulations of tar in the valve port will change the rangeability of the control and should not be allowed to build up.

7. A.T.C. Balancer and Relatrol

a. The Valve Operator

The resistor and contactor in the valve operator should need no attention for the life of the unit.

b. Cleaning the Relay Contacts

The contacts of the Bridge Relay, which is a part of the Balancer Relay, should be cleaned with a fine contact-file every three months, or more often if the unit is installed in a dusty or gaseous atmosphere.

Inspect the contact arm occasionally to see that it is properly balanced. Turn off the power switch before making this inspection. The contact arm should assume a mid-position between the contacts. If it does not, slightly move the pigtail wire connected to the contact arm, to bring the arm to mid-position.

In addition to the above contacts, the Balancer Control system has a single-pole double-throw contact labeled "Load Compensation". Regularly inspect this contact and clean it if necessary.

c. Lubrication

Lubricate the valve operator every six months with a good grade of light machine oil. Refer to instructions furnished with the mechanism for the location of points requiring lubrication.

8. Program Control

From time to time, and frequently if the atmosphere is dusty or dirty, carefully clean the contacts of any relays with a soft cloth.

Every six months cover the relay contacts with a very thin film of vaseline or similar jelly. Also give the relay shaft a drop of oil at this time.

The auxiliary switch mechanism should require no attention or lubrication throughout its life.

The control point drive mechanism should require little attention beyond a periodic lubrication of the moving parts with a good grade of light oil, approximately every six months. The self-contained motor and gear reduction is lubricated and sealed and requires no further attention.

The individual instructions for the soaking time controllers and rate controllers indicate the necessary maintenance for those units.

9. Auxiliary and Interrupter Switches

Add a few drops of oil on the roller and bearing of the switch bracket once a month.

No additional maintenance should be necessary throughout the normal life of the instrument. If the mercury switch should be damaged by overloading, order a replacement switch. On the order, state the model number of the instrument, which appears on the nameplate.

10. Repairs and Service

If parts are necessary for repair, order them by specifying the serial number or part number. If this information is not available, include a description of the part together with the serial number of the assembly.

In requesting information regarding any instrument or one of the accessories, submit all the data contained on the nameplate.

SECTION 1309
Issue 1

LUBRICATION OF THE BROWN TYPE 113 POTENTIOMETER PYROMETER AND RESISTANCE THERMOMETER

Adding a drop of oil occasionally on all bearing surfaces and keeping the instrument clean at all times will add immeasurably to the life of the instrument and related parts.

The frequency of oiling and cleaning will depend on the operating temperatures and amount of dust and dirt which may get into the instrument. Under average conditions, oiling and general cleaning once a month with a thorough cleaning once a year will be satisfactory.

A. LUBRICATING THE INSTRUMENT

Lubricate all bearings and sliding surfaces monthly with a light oil preferrably the instrument oil – our Type L-1.

The exception to the above is the sliding contact between the two drive pawls and also between the secondary pointer positioner and the table cam lever. These sliding surfaces should be dry and clean in order to operate properly. After lubricating, check these surfaces and wipe with a clean rag; also wipe off dirt and excess oil on the side plate.

Oil the ball bearing kidney cam follower on the step lever with our oil Type L-1 or equivalent and pack all other roller or ball bearings with our grease Type L-7 or equivalent.

Figures 1309-1, 2, 3, and 4 are charts showing the main bearings to be lubricated once each month.

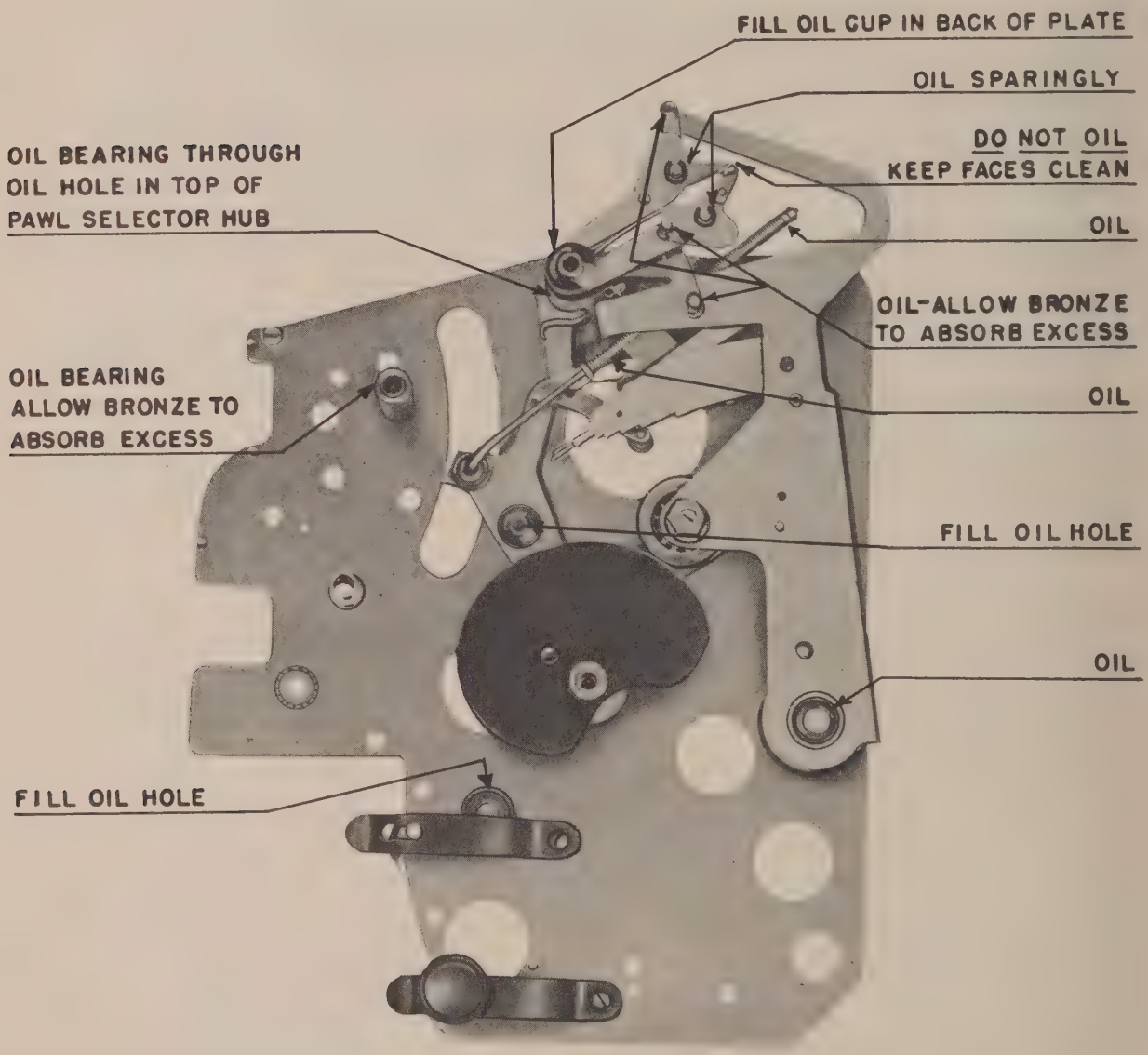


Figure 1309-1 - Oiling Chart

Right-Hand Side Plate of Single
Record Mechanical Potentiometer

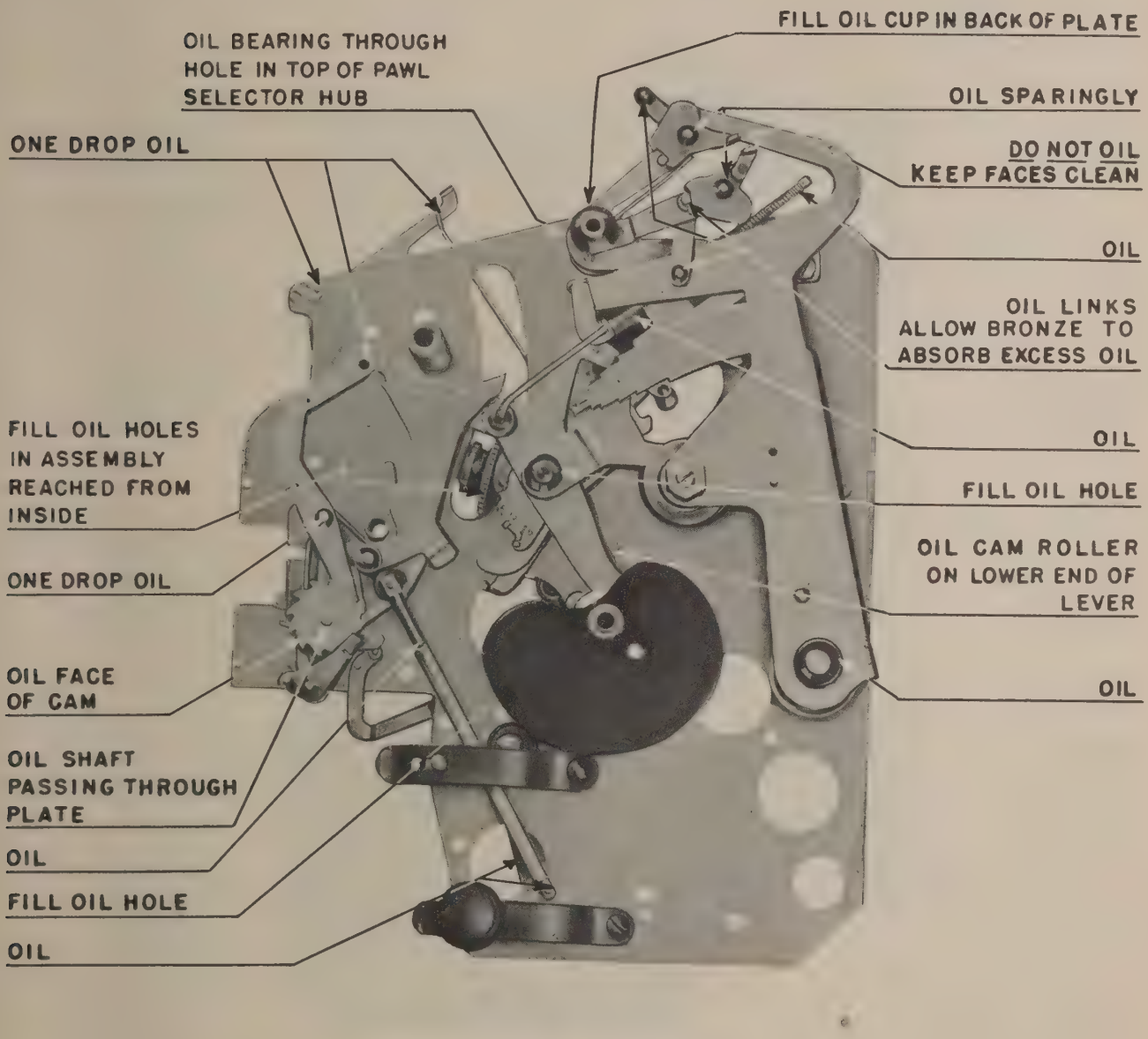

FILL OIL CUP IN BACK OF PLATE
OIL BEARING THROUGH HOLE IN TOP OF PAWL SELECTOR HUB
OIL SPARINGLY
ONE DROP OIL
DO NOT OIL KEEP FACES CLEAN
OIL
OIL LINKS ALLOW BRONZE TO ABSORB EXCESS OIL
FILL OIL HOLES IN ASSEMBLY REACHED FROM INSIDE
OIL
FILL OIL HOLE
ONE DROP OIL
OIL CAM ROLLER ON LOWER END OF LEVER
OIL FACE OF CAM
OIL
OIL SHAFT PASSING THROUGH PLATE
OIL
FILL OIL HOLE
OIL

Figure 1309-2 - Oiling Chart

Right-Hand Side Plate of Multiple Print Hammer Mechanical Potentiometer

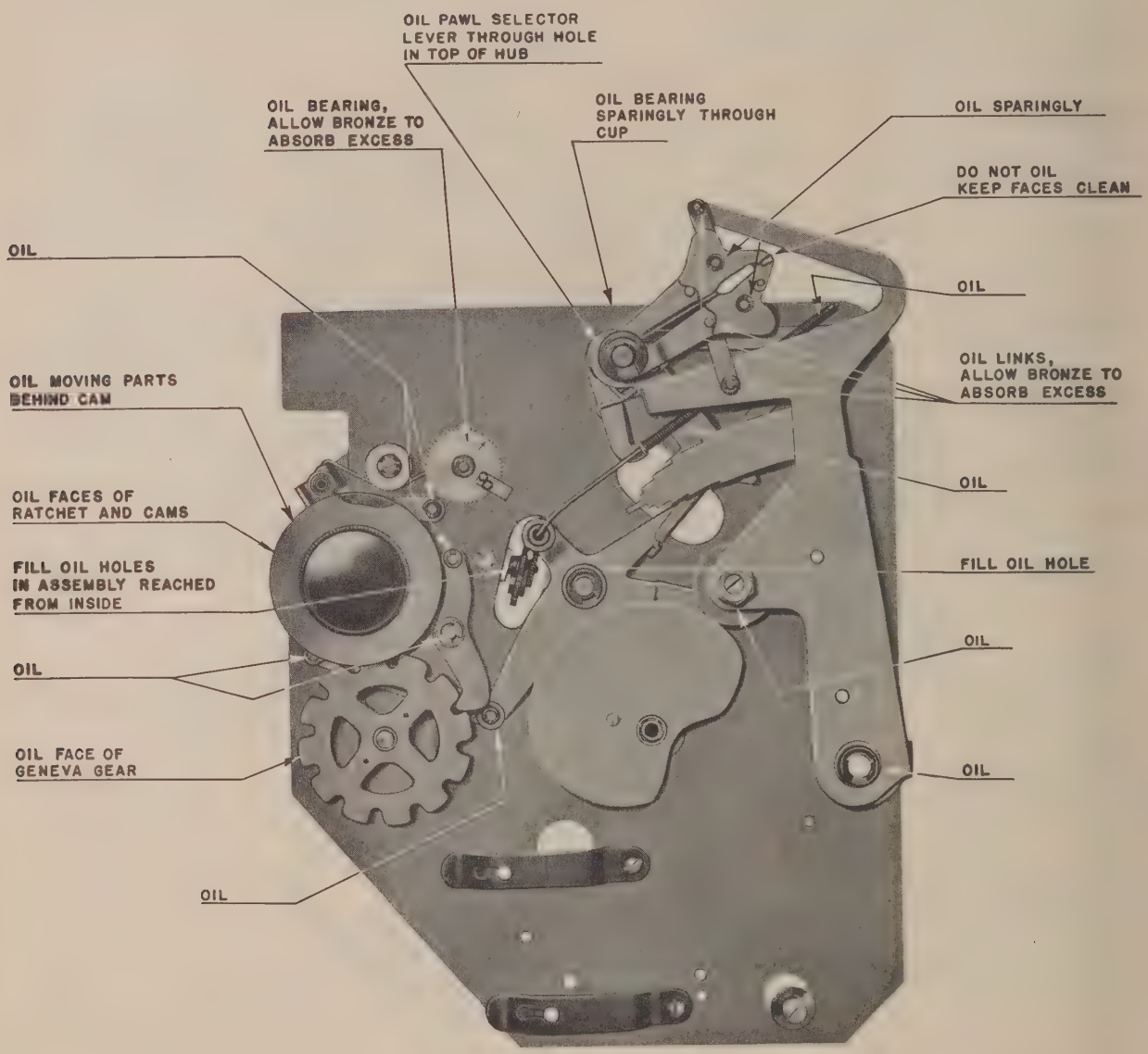


Figure 1309-3 - Oiling Chart

Right-Hand Side Plate of
Multiple Record Print Wheel Mechanical Potentiometer

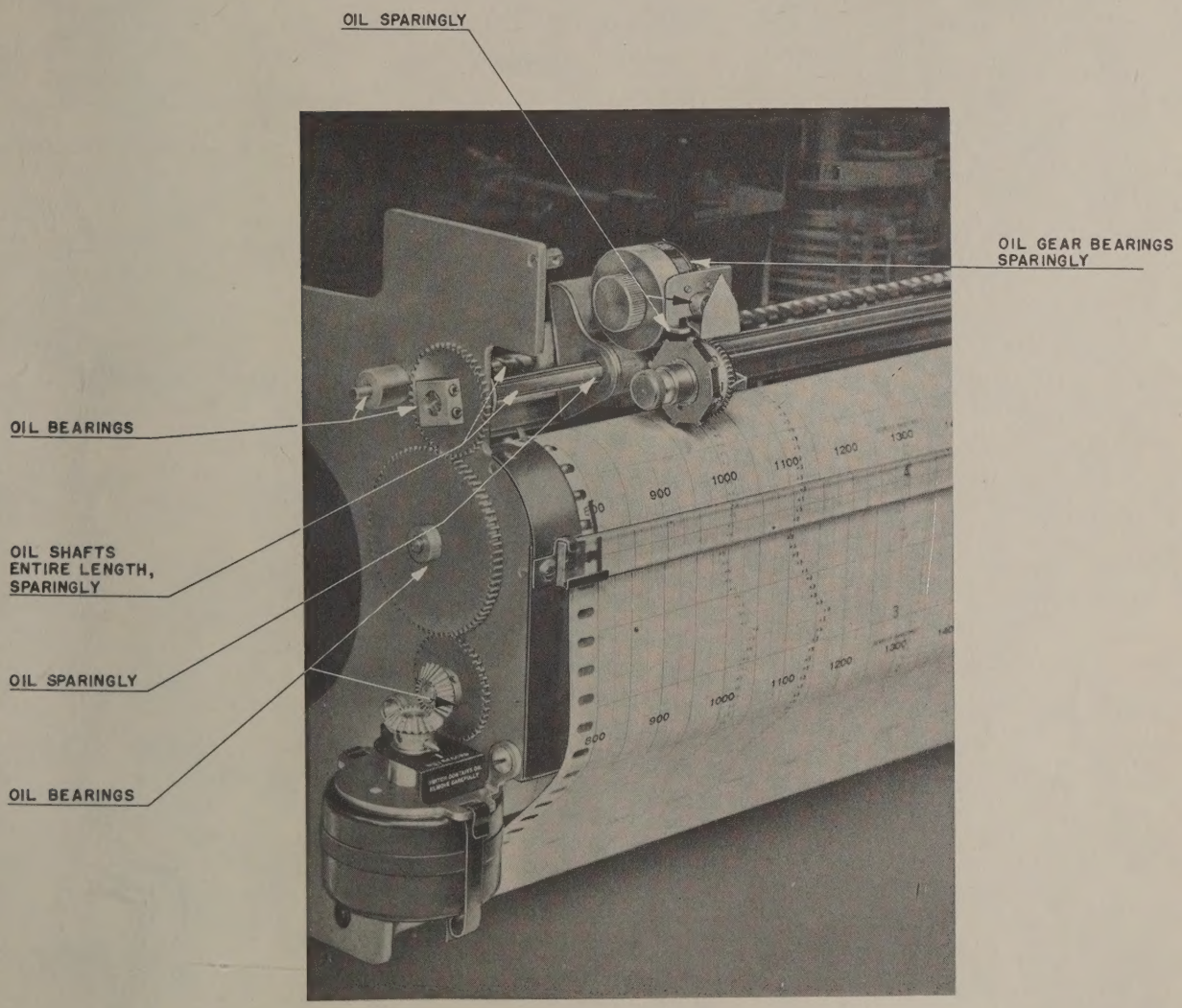


Figure 1309-4 - Oiling Chart

Left-Hand Side Plate and
Print Wheel Carriage of Multiple
Print Wheel Mechanical Potentiometer